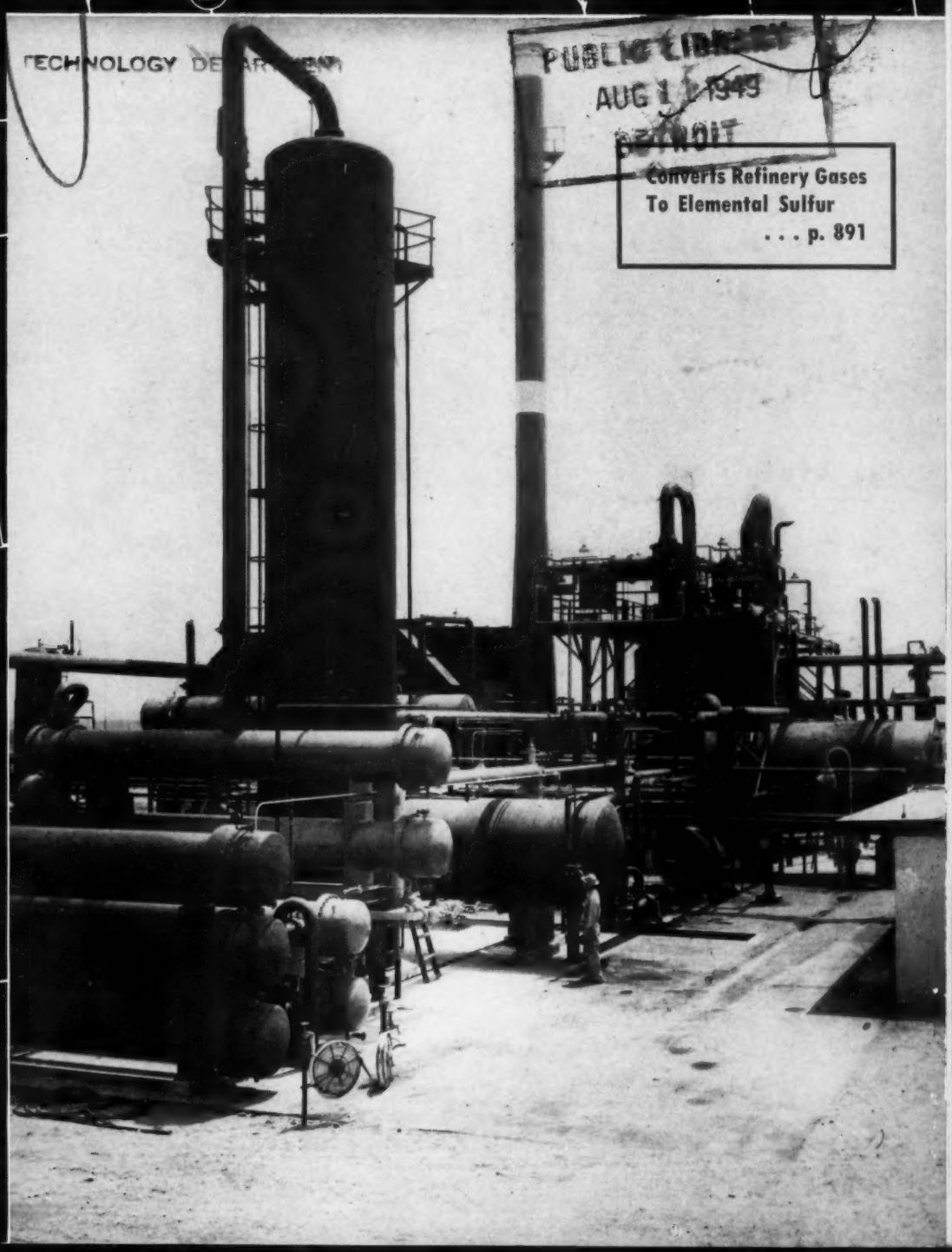
AUGUST, 1949
VOL. 4, NO. 8

PETROLEUM PROCESSING



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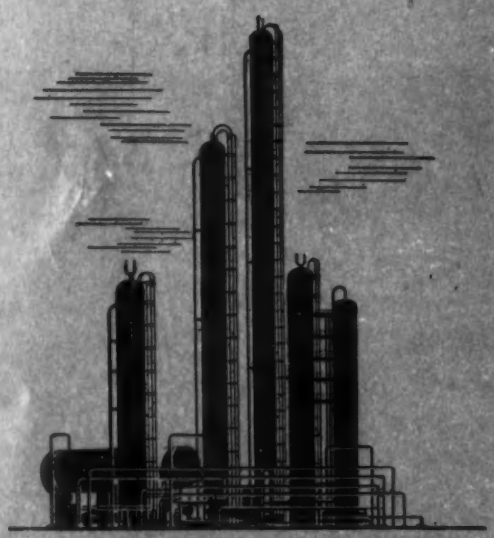
DETROIT

Converts Refinery Gases To Elemental Sulfur
. . . p. 891



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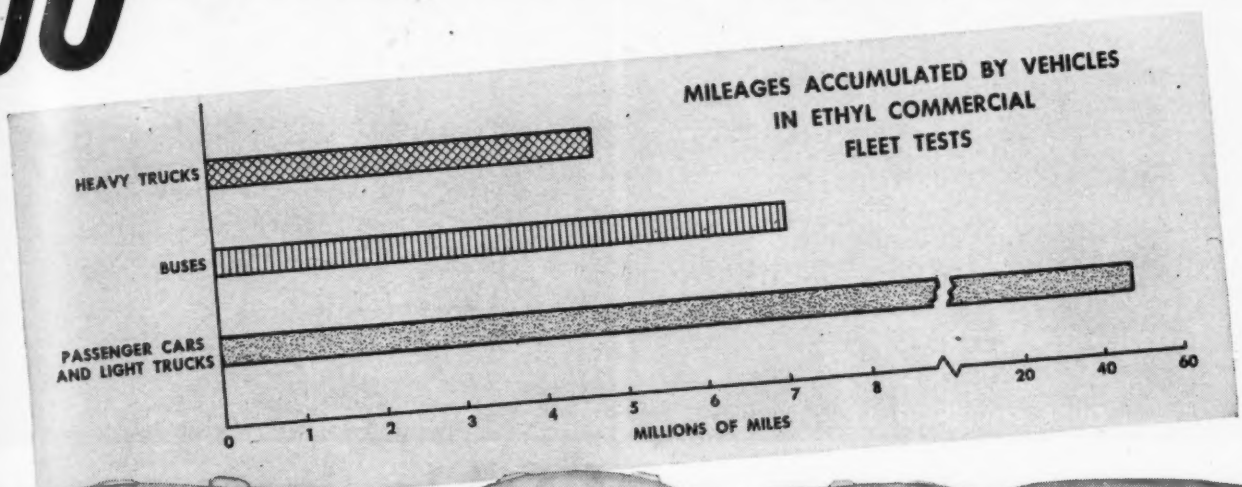

Cooperative tests, made possible by Ethyl's close relations with automotive companies and operators of commercial fleets, have provided information on more than 60,800,000 miles of road operation. Commercial fleet testing is the final step in Ethyl's extensive research program aimed at developing the best antiknock fluids for the oil industry.

Refiners benefit two ways

In addition to contributing to continually improved antiknock fluids, Ethyl's carefully controlled fleet programs provide refiners two major benefits:

1. **Basic information on the performance of different types of gasolines and oils operating under a wide range of service conditions . . .**

   thus refiners often find it possible to reduce the amount of expensive fleet research necessary to obtain similar basic data.

2. **A fund of information on improved maintenance practices which often point the way to more satisfactory use of petroleum products.**

Although the Laboratories each year conduct thousands of hours of research on single-cylinder engines, on full-scale engines connected to dynamometers, and on Ethyl-owned fleets of passenger cars and trucks at Detroit and San Bernardino, they have never been satisfied to accept the results of any one of these steps as the final answer in the development of "Ethyl" antiknock compounds.

How Ethyl fleet research is conducted

Ethyl commercial fleet tests are planned to be representative of the types and makes of vehicles in production, the variety of loading and operating schedules normally employed, and the weather and topographical conditions encountered in service in different parts of the country. Comprehensive control of each cooperative program is the responsibility of an experienced Ethyl engineer. He works out the details of the test with the management of the fleet and makes certain that procedures and controls provide reliable data . . . without introducing changes in the operation which would destroy the usefulness of the fleet as an index of commercial operation.

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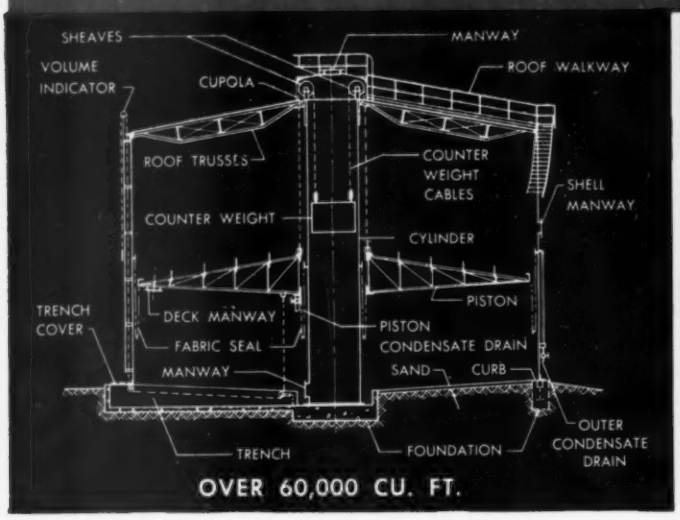
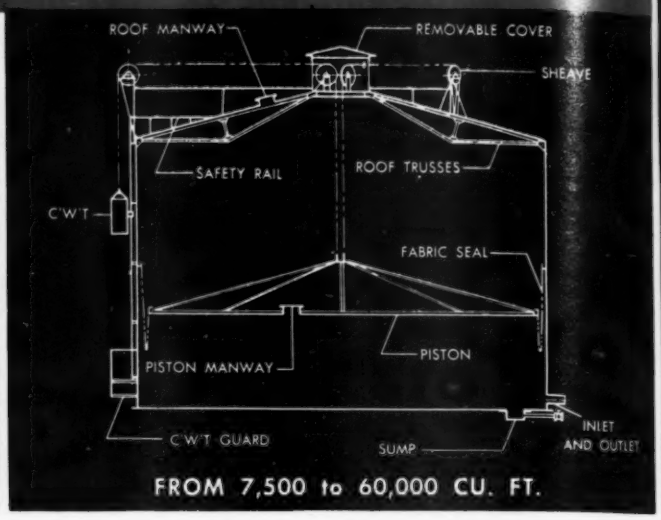


OVER 60,000 CU. FT.



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What's Happening!

Important Current News Summarized for Refiners

EXPANSION

Indiana Farm Bureau Co-operative Assn. will install a 4000 b/d (of fresh feed) fluid catalytic cracking unit at its Mt. Vernon, Ind., refinery. Engineering design by Universal Oil Products Co., Chicago.

Humble Oil & Refining Co. has awarded W. S. Bellows Construction Corp. of Houston the contract for the second unit of a central shops building at Baytown estimated to cost $1 million. A third unit is contemplated. Tellepsen Construction Co. at Houston will construct a 2-story locker building to cost $100,000.

The Alba Oil & Refining Co. is reported ready to start work soon on a 1000 b/d refinery at Alba, Texas.

Cities Service Oil Co.'s $4-million lube compounding plant at Cicero, Ill., is now under construction with completion scheduled for July, 1950. S. S. Sollit & Co., Chicago, is contractor.

Imperial Oil, Ltd., will increase plant capacity at Regina, Sask., Canada, 3000 b/d by additions to crude distillation facilities, part of which were destroyed by fire. New capacity will be about 16,000 b/d.

Sinclair Refining Co. has completed a MEK dewaxing unit as the last part of its revamped lube facilities. Unit will handle 5200 b/d of neutrals, 3200 b/d of bright stock and de-oil 2630 b/d of wax.

Work at The Texas Co.'s West Tulsa refinery has been resumed following labor dispute with contractors on the $25-million expansion program.

Union Oil Co. of California will construct a $5-million central research laboratory near Brea, Calif. Replacing present Wilmington facilities, the new center will provide 120,000 sq. ft. of floor space in 12 buildings, and is scheduled for completion September, 1950.

General Petroleum Corp. has begun construction at its Torrance, Calif., refinery on a $2,250,000 expansion project to turn more surplus heavy fuel oil into lighter products, by increasing the capacity of its 15,000 b/d "coker" over 50% and possibly as much as 80%. The project will add two more coke drums and another furnace, with design engineering by M. W. Kellogg and construction by Bechtel Co. Completion is scheduled for early 1950.

• • •

NATURAL GASOLINE PLANTS

Humble Oil & Refining Co. is increasing compressor capacity by 10,000 Mcf. at its Tomball, Texas, gasoline plant to handle all casinghead produced in the area. Equipment includes 2200 hp. of compressors and auxiliaries and a new cooling tower for the plant. No changes will be made in processing system. Fluor Corp., Ltd., is contractor with completion scheduled this month.

Pure Oil Co. as operator for nine joint owners will construct a $6-million natural gasoline plant in the Dollar Hide field of Andrews Co., Texas, to handle 22,000 Mcf. of gas. Compression facilities are scheduled for operation in Jan., 1950; balance of plant by July. Hudson Engineering Co., Houston, is contractor.

Stanolind Oil & Gas Co. has completed its Stano natural gasoline plant near Ulysses, Kans. Processing 100,000 Mcf. of gas daily, it will recover 26,600 gal. of natural gasoline and 36,600 gal. LP-gas daily.

• • •

FOREIGN

The Brazilian government is increasing capacity of its plant at Bahia by 3000 b/d to 5000 b/d total; plans to buy steel from France for a 45,000 b/d plant to be built either at Rio de Janeiro or Sao Paulo.

ECA is partially financing a $7,950,000 project to rehabilitate lube and reforming facilities at the Trieste, Italy, plant of Aquila S.P.A. Technico Industriale. Most of the equipment will be bought in the U. S.

Dominican Republic government has approved plans for construction of the country's first refinery, with 5000 b/d capacity initially and 25,000 b/d eventually. Project will be built in vicinity of Ciudad Trujillo. The initial 5000 b/d installation will cost an estimated

Information on these pages is obtained through the nation-wide news coverage services of PLATT'S OILGRAM NEWS

$6-million, and is scheduled for completion by the end of 1951. International Industrial Consultants has been assigned the job of constructing and operating the refinery.

Vacuum Oil Co., Pty., Ltd. has put on stream a new 1200 b/d refinery near Melbourne, Australia, whose primary product will be high grade industrial lubricating oil. Plant program calls for about 326 b/d of lube oils, 353 b/d of Diesel fuel, 310 b/d of asphalt, and a small quantity of gasoline. The $3-million refinery is at Altona on Port Phillip Bay.

• • •

MARKETS, PRICES

Steadying of prices after long declines appeared during July in most of the nation's refinery districts with the possible exception of Chicago. Steadier price trends, notably for fuel oils, were attributed by refiners to conversions from coal to heavy fuel, increased interest in summer stockpiling, and growing confidence in generally posted crude oil prices at current levels.

Crude oil markets were unchanged for the most part, with the exception of piecemeal adjustments in some areas. Humble Oil & Refining Co. returned 25 low gravity Mirando grade fields to pre-war relationship with other Texas Gulf Coast crudes by posting a 10c per bbl. reduction, effective July 11. In Michigan, Pure Oil Co. and other buyers posted an average cut of 11c per bbl.

Greater stability in fuel oil markets was thrown into sharp relief by a rise of 10c per bbl. in No. 5 oil cargo prices and 15c for Bunker "C" at the Gulf. Over the past 60 days, purchases of heavy fuel, for the most part by major company buyers, have exceeded 1-million bbls. The upward move in "C" fuel cargo prices from $1.20 to $1.35 per bbl. reflected fairly active demand working against diminishing supply.

In order to encourage summer stockpiling, many leading marketers in the east and midwest offered their customers summer discount plans on purchases of kerosene, No. 2, and Diesel fuel. Heating oil discounts to consumers and resellers generally averaged 0.6c per gal. off posted prices in July and 0.5c in August.

Lubricating oil prices continued weak. A part-cargo parcel of western bright stock was reported sold at 16.25c per gal., FOB ship, the Gulf, for export. There were many unfulfilled export requirements for lubricating oils because of continued difficulties over money exchange and import permits. This problem can easily become more acute as the wax and lubricating oil capacity of the nation is enlarged through new construction during the balance of the year.

SYNTHETIC FUELS

Public demonstration of oil shale mining will be held at Bureau of Mines' experimental mine near Rifle, Colo., from Sept. 7 through Oct. 1, director James Boyd announced July 23. Month-long test run will demonstrate unique equipment and practices employed in achieving low-cost volume production of oil shale. Observers planning to attend the demonstration should send inquiries to Emery M. Sipprelle, Bureau of Mines, Rifle, Colo.

A 200 b/d experimental shale oil refinery was placed on stream at the Bureau of Mines' Oil-Shale Demonstration plant about the middle of June, Bureau officials have revealed. The refinery is described in a Bureau press release as "a highly flexible unit that will produce gasoline, Diesel fuel, heating oils and fuel gas." It has facilities for topping, cracking to coke and recycle cracking, sulfuric acid treating, rerunning naphtha, and doctor sweetening.

• • •

SYNTHETIC RUBBER

Closing of two synthetic rubber plants owned by the government in the Los Angeles area has been ordered by the Reconstruction Finance Corp. They are the butadiene plant at El Segundo, with a rated capacity of 18,000 short tons a year, operated by California Standard, and the copolymer plant at Torrance, with a rated capacity of 30,000 long tons a year, operated by Goodyear Synthetic Rubber Corp. The butadiene plant will be shut down about Sept. 1, and the copolymer plant a month later.

Questionnaires have been sent to some 800 officials of petroleum, rubber and chemical companies to get their views on a long-range synthetic rubber program for the U. S. Survey is being made by an inter-agency committee established by the White House July 20, under chairmanship of Robert C. Turner, to prepare a report on recommendations on the subject, which the President is required to submit to Congress by next January. All interested oil company officials have been invited to submit their views, whether sent a questionnaire or not.

• • •

MISCELLANY

Fire at the Baltimore refinery of Esso Standard Oil Co. July 21 destroyed two re-run heating oil stills and resulted in fatal burns to two employees. Product leakage was apparent cause, according to company.

A symposium on diesel fuels will be held by the Western Petroleum Refiners Assn. during its regional technical meeting at Leonard Refineries, Inc., Alma, Mich., Aug. 19.

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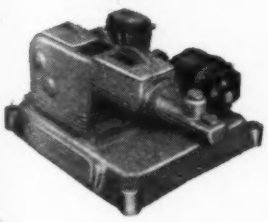
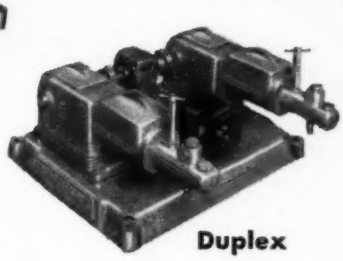


Simplex



Duplex

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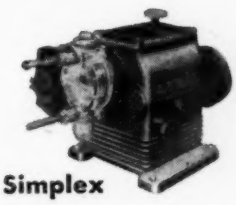

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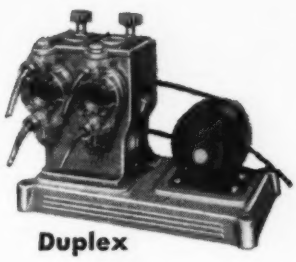

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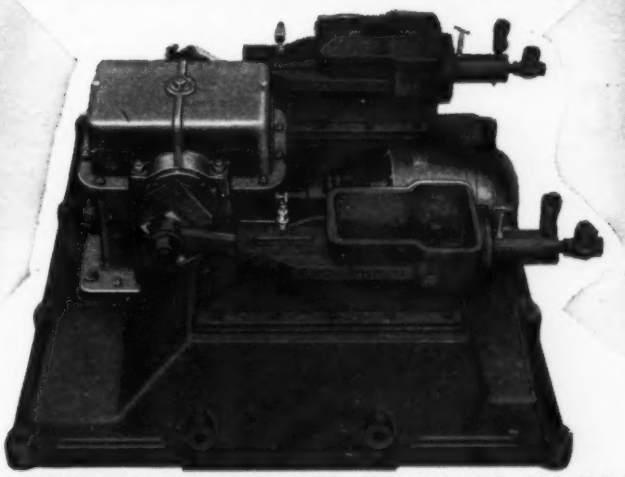

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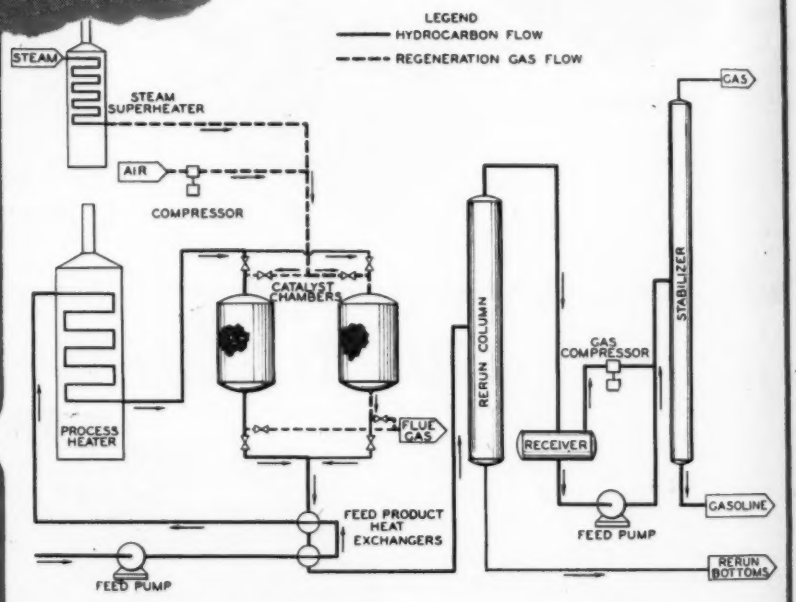

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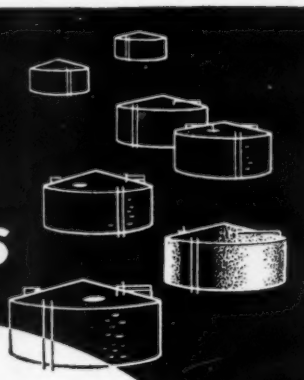

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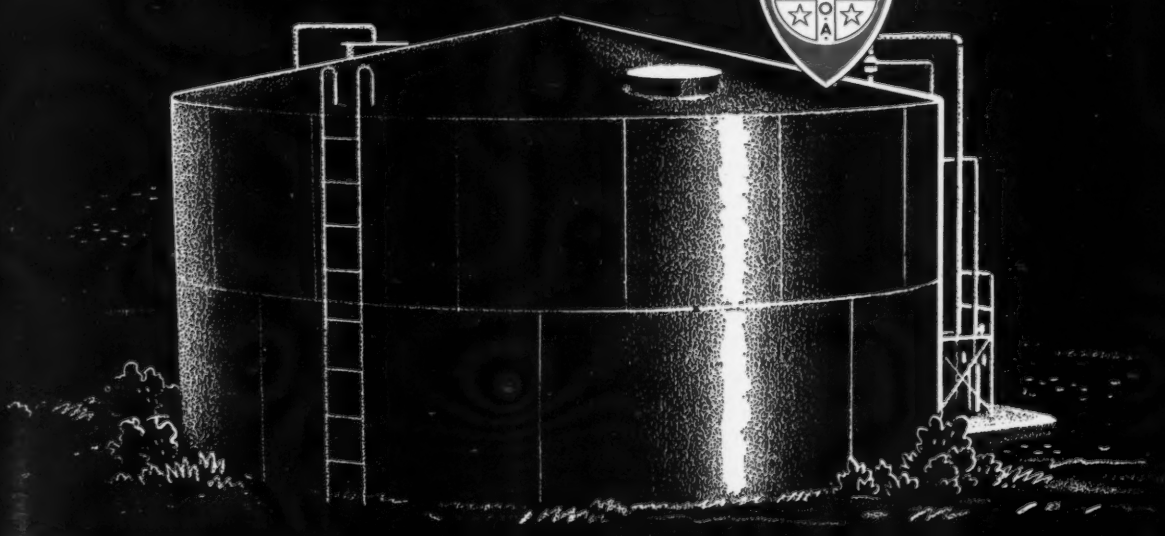

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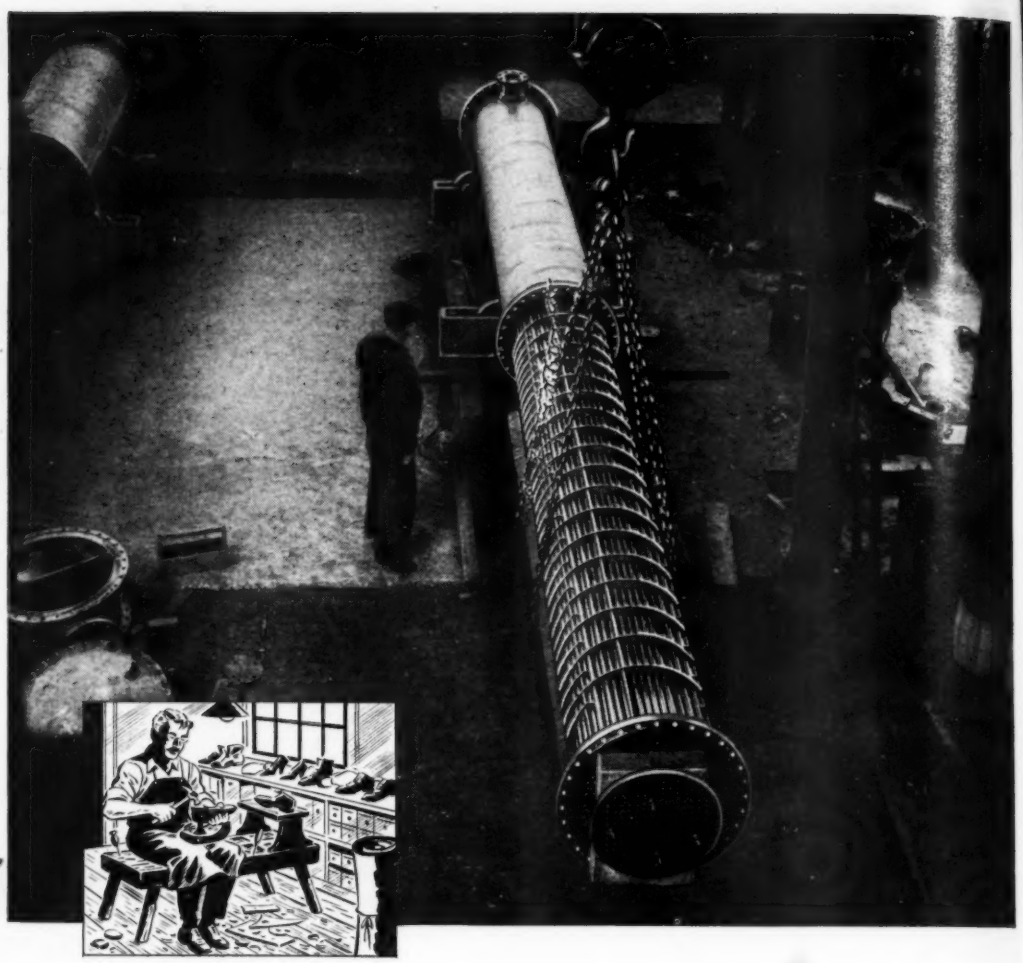

Will it be a good fit?

FABRICATING a heat exchanger shell might be compared to making a pair of shoes. You can make them relatively easily but will they fit when you put them on.

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That's pretty much the story with exchanger shells. They must be fabricated to close tolerances if they are to serve their purpose efficiently. A shell that's made "a size too large" through lack of skill or mistaken economy doesn't make an effective heat exchanger, because the fluid that must pass in close contact with all the tubes in the bundle "escapes" around the outside due to the extra space. Baffles fail to divert it sufficiently to overcome this fault.

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Tomorrow

. . . IN PETROLEUM TECHNOLOGY

By B. H. WEIL, Atlanta, Ga.
Editor, "Monthly Summary of Industrial Developments"

Brief reviews of currently reported technological and economic developments, in the light of their potential bearing on petroleum refining

Lubricant Reclaiming Will Receive Panel Study

ALMOST LOST in the hubbub over the 1000-mile oil drain situation and the new heavy-duty, high-additive-content crankcase oils was the approval of a motion at the recent API Lubrication Committee's meeting for the creation of a panel to study aspects of the re-refining of lubricating oils. D. P. Clark of the Gulf Oil Corp., chairman of the API committee, pointed out the growing importance of the use of reclaimed lubricants by stressing the increased use of such oils by the air force, while H. P. Hobart, also of Gulf, suggested that road tests of reclaimed and virgin oils be performed and results released to the public in order to discredit some of the extravagant claims currently being made by some lubricant re-refiners. Also stressed at the meeting was the fact that re-refined oil is tax free.

As mentioned earlier this year,(1) lubricant reclaiming, long a disowned stepchild of the petroleum industry, is now proceeding at such a pace—a growing pace—that refiners can no longer afford to ignore its existence. Until recently, it had long been a petroleum industry contention that re-refined oils were, *per se*, inferior, regardless of the reprocessing steps employed. However, in the past few years—since 1940, and abetted by the war—so many large users of lubricants have installed their own reclaiming equipment and re-used their oils without identifiable trouble, and so many independent re-refiners have erected plants and are selling their services and products in the open market that it is highly understandable and highly important to the industry and to lubricant users alike that the API Lubrication Committee should call for a scientific study of the entire situation.

It is highly important, of course, that this study should be strictly impartial, that the data obtained from the reclaimed oils tested should be correlated with the sources of the used oils, the exact steps used to reclaim them, the additives employed, etc. There is no doubt that some lubricant re-refiners employ equipment that is inadequate to produce "safe" products, but it also seems fairly clear that others reprocess their oils by a series of physical and chemical treatments which yield products of apparently high quality.

Space does not permit much further comment on the technical or economic aspects involved in the reprocessing of used lubricants and in the use of the reclaimed oils obtained. One petroleum technologist recently commented that in *normal* times—and except on a large scale, such as 5,000-10,000 bbls. per month—it is usually cheaper to purchase virgin lubricant blending stocks in bulk than to re-refine used oils, because of the extensive processing required. However, many small re-refining plants continue to operate, apparently at a profit, and many large users of lubricants continue to re-process their oils in "small" plants.

Automotive, Rail Industries Study Gas Turbines

AVIATION-INDUSTRY research on and growing use of gas turbines and jet power plants have served somewhat to obscure the fact that these power units have other potential uses or at least have been considered for other applications. Occasionally, one reads of work on the use of gas turbines for stationary power plants and for ship propulsion, but, except for rumor-type reports, little of value has actually been printed on the use of gas turbines for railroad engines and automotive vehicles. On the basis of recent information, however, it appears that the economics and technical aspects of these two applications are rather far apart.

According to a recent SAE paper(2) by W. A. Tururen of General Motors Research Laboratories Division, the use of gas turbines for automotive power does not appear imminent. Disadvantages include: (1) high fuel consumption, especially at part throttle; (2) need for complicated controls and limiting devices, to insure safe operation; (3) large space requirements; (4) probable higher first cost; (5) probable higher maintenance cost, especially if high operating temperatures are employed; (6) probable objectionable exhaust; (7) sensitivity to changes in ambient temperatures; (8) possible need for a separate device to produce braking torque; (9) noise-silencing might present a difficult problem; (10) a necessary large reduction gear ratio; and (11) the low power requirements of automotive engines, "too low to show the turbines to their best advantage."

The desirable features of gas turbines in automotive installations were said to include "(1) the turbine produces maximum torque at standstill with uniform variation to maximum speed, (2) a transmission with only one ratio change would be required, and (3) a clutch mechanism might not be required." However, as Tururen points out, "these features are also realized when a conventional engine is equipped with an automatic transmission . . . The turbine appears to offer the following advantages: (1) operation with a large range of fuels would be possible, (2) the absence of power impulses would probably reduce the vibration problem, (3) the lubrication problem may be simplified, and (4) electric ignition is required only for starting."

As regards railroad locomotives, it has been reported(3) that the Union Pacific Railroad will place an oil-burning, gas-turbine-electric locomotive into revenue service this summer. This locomotive has been built by General Electric and the American Locomotive Co., but a host of other organizations are known to be working on their own gas-turbine-driven locomotives—Westinghouse Electric, Lima-Hamilton, Allis-Chalmers, the Elliott Co., Fairbanks Morse, etc. Some of this work is devoted to the development of coal-burning gas turbines; Bituminous Coal Research, Inc., has recently been said(4) to have discovered improved methods of fly-ash removal which have eliminated much of the "trouble from slagging and burn-out due to after burning in the separators"; 98% combustion efficiencies are said to have been obtained in experimental units, although turbine efficiencies were not given.

The advantages of gas turbine power plants for railroad engines are

(1) "Tomorrow in Petroleum Technology—Lubricant Reclaiming at Accelerated Pace," PETROLEUM PROCESSING 4, No. 2, 118 (1949).

(2) W. A. Tururen, "Gas Turbines in Automobiles," Preprint of paper presented at SAE 1949 Summer Meeting, June 8, 1949.

(3) Anon., "Rail Portent: Gas Turbine," *Business Week*, No. 1033, 83 (1949).

(4) Anon., "In Several Years," *Chemical and Engineering News* 27, No. 24, 1707 (1949).

said[3] to include higher capacity from single units and longer overhaul intervals. Unknowns include fuel consumption—"the power plant (at present, at least) is less efficient than a Diesel," although it is hoped that this can be improved later; the effect of weather—more power is delivered in cold weather; variations in locomotive weight—low traction is feared when the fuel supply is low; etc.

The petroleum industry has already focused concerted attention upon the provision of jet and gas turbine fuels for aviation uses. It can well be expected to view potential railroad demand with more than interest, especially if such demand would call for residual fuel oil, a product which is rapidly losing ground to Diesel fuels as regards railroad use. As regards automobile use of gas turbine power plants, it would appear that this "threat" to the gasoline-fueled internal combustion engine will be long aborning.

Future of Detergents Under Discussion

STATISTICS are wonderful tools with which to support contentions. Numerical trends can be employed to predict future developments —or they can be ignored or explained away by citation of factors which are expected to bring about abrupt changes. The real truth of the matter, of course, is that statistics must be reliable and adjustable to a common base and that they must be intelligently qualified and interpreted if their use is to be of real value in predicting future trends or explaining past happenings.

It should be with trepidation, therefore, that any soul would venture to survey recent statistics of the synthetic detergents industry and to interpret their meaning. First of all, few of the statistics available are much more than informed estimates and, being estimates, it is little wonder that they do not agree closely. Secondly, those who release their estimates rarely agree on a common base; some adhere rigidly to the basis of "100% active material" (although few detergents are so prepared and sold), while others employ figures which represent the finished products (including builders and other additives), usually on a "35-40% active material basis." It is small wonder, then, that detergent industry spokesmen do not also agree as to trends.

Looking at specific figures, it may be noted (employing a 100% active material basis, for the sake of consistency) that A. B. Hersberger and C. P. Neidig of the Atlantic Refining Co. recently estimated that the 1948 production of all surface-active materials approximated 253,000,000 lbs, not including cationics and petroleum sulfonates. Of this total, somewhat more than 90,000,000 lbs. reportedly went into the household package market (approximately 24% of the total packaged soap market), while somewhat less than 163,000,000 lbs. were used as industrial surface-active agents and as materials for miscellaneous household applications.

However, on the above (100%) basis, Robert M. Prather of the Indoil Chemical Co, recently estimated that the 1948 production of surface-active agents totaled 210,000,000-240,000,000 lbs. (slightly less than the Hersberger-Neidig figure) and that —and here the divergence in figures is greater—two-thirds of this total (140,000,000-160,000,000 lbs.) went to the household market, with only one-third of total production (70,000,000-80,000,000 lbs.) going into the industrial field. On this same (100%) basis, John W. McCutcheon, a chemical consultant, has placed 1948 surface-active-material sales at 157,500,000-180,000,000 lbs. "retail" and 122,500,000-140,000,000 lbs. "industrial," for a total of 280,000,000-320,000,000 lbs.

All that can be derived from these estimates is that 1948 production of synthetic surface-active materials was somewhere between 210,000,000 and 320,000,000 lbs., on a 100% active material basis, and that 90,000,000-180,000,000 lbs. of this total went into household materials, presumably almost entirely packaged products (300,000,000-450,000,000 lbs. of actual products when builders and other additives are included). These ranges are far too wide for quantitative comparison with figures for other years.

Getting back to Hersberger-Neidig figures, it is interesting to note that they place this country's present surface-active-material capacity at more than 400,000,000 lbs. of 100% active material (46% alkyl aryl sulfonates, 22% sulfated alcohols, 8% nonionics, and 24% sulfates and sulfonates), while tentatively placing predictable potential demand at 300,000,000-325,000,000 lbs. on the assumption that industrial uses will continue at the 1948 rate (new applications counterbalancing leveling off industrial activity) and that synthetic detergent use will increase to 40% of the household package business. "When one considers this potential demand along with the productive capacity of this country, it indicates that renewed effort must be placed on finding new applications and developing expanding consumption in present uses if this industry is to remain healthy and continue to grow."

Bramston-Cook of the Oronite Chemical Co. is recently said, also, to have estimated that the detergent production capacity of this country by the end of this year will be in excess of predicted 1952 sales of 350,000,000-400,000,000 lbs. (100% active material basis), but John W. McCutcheon feels that production of detergents might even be doubled in the period from 1950-1952. Others point to a lull at present in plans for additional plants, pointing out that soap manufacturers are making their soap products more competitive, partially because of decreases in the costs of fats and oils.

What the future will hold for the production of synthetic detergents—a field in which petroleum hydrocarbons are major raw materials—seems far from clear. Near-future growth of sales may be of limited scope, although advertising, sales campaigns, and improved products may change this picture greatly within the next few years, as may also an easing in present difficulties in arranging for the financing of new plants (said to have caused one large petroleum company to drop a detergent project). In the meanwhile, all that any analyst can do is to carefully weigh industry statistics and trends and to interpret them as best he can. A crystal ball might be quite helpful.

Competition Imminent In Antifreeze Market

A REAL CUT-THROAT FIGHT for the antifreeze market may not eventuate this year, but recent indications point to a near-future return to prewar conditions in which ethylene glycol and methanol slugged it out (successfully for them) with ethyl alcohol antifreezes.

That ethyl alcohol producers do not intend to accept such a return meekly is evidenced by a recent cut to $1 per gallon by some manufacturers of ethyl alcohol antifreezes, from a previous level of $1.40-$1.50. At the time of the cut, methanol-type antifreezes were priced at $1.25-$1.35 per gallon, while permanent-type (glycol) anitfreezes were priced (retail) at $3.50. Since that date, however, methanol prices have been reduced two cents per gallon at the producers' level, in order partly to meet this cut, although methanol producers are said to be placing greater reliance on such technical advantages as a constant-boiling mixture and greater temperature protection per gallon to maintain their competitive position.

Present price disparities are sufficiently large, however, to indicate that aggressive advertising may be expected to boost sales of ethyl alcohol antifreezes, at least for the coming season. What the future holds is far less certain unless methanol and ethylene glycol prices fail to come down or ethyl alcohol prices rise again sharply. The latter is not a probability, despite a July 1 price increase of nearly ten cents per gallon by ethyl alcohol producers.

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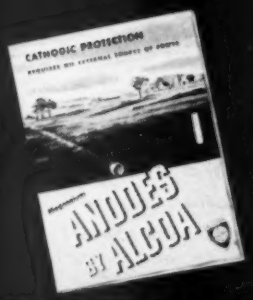

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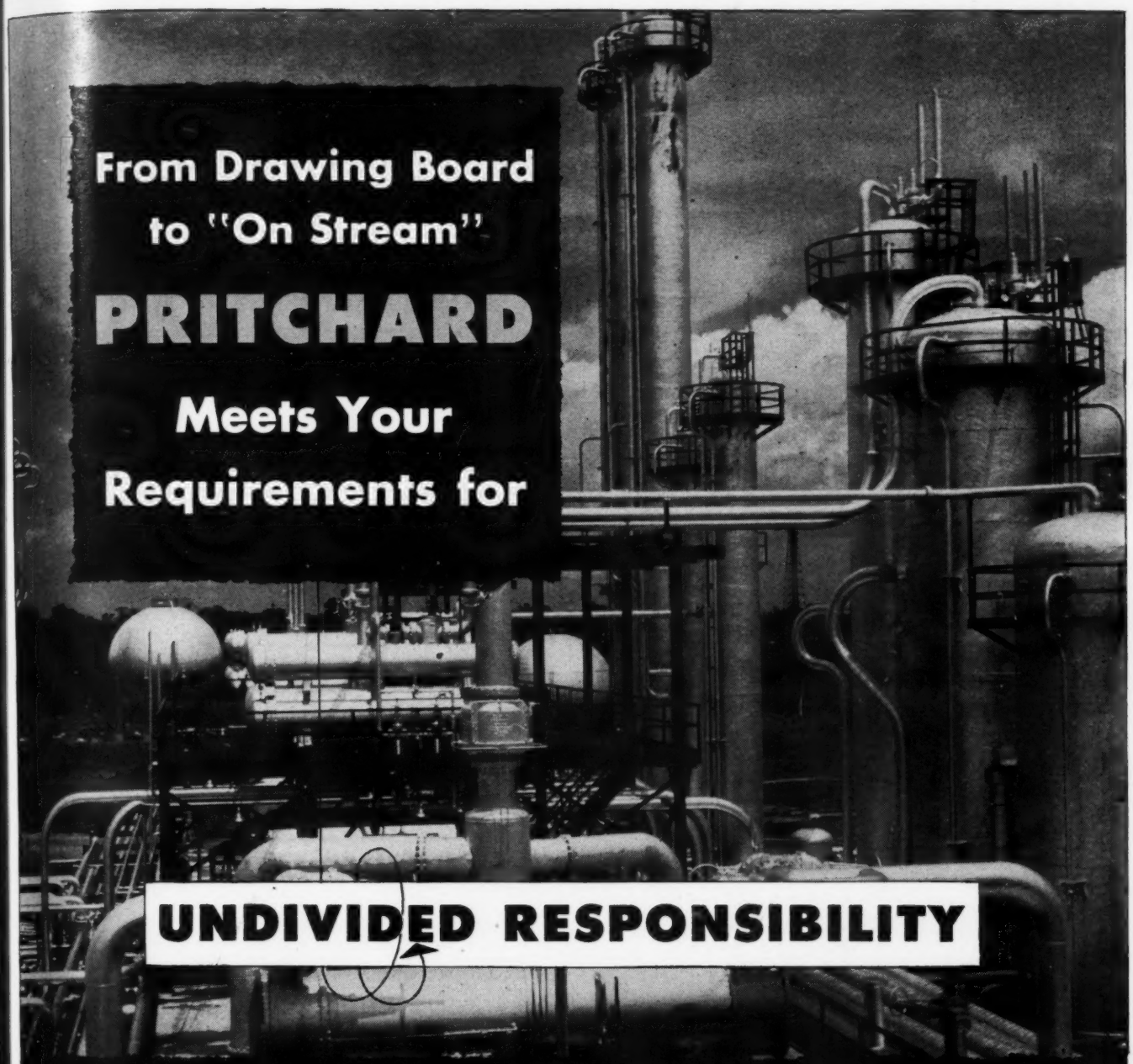

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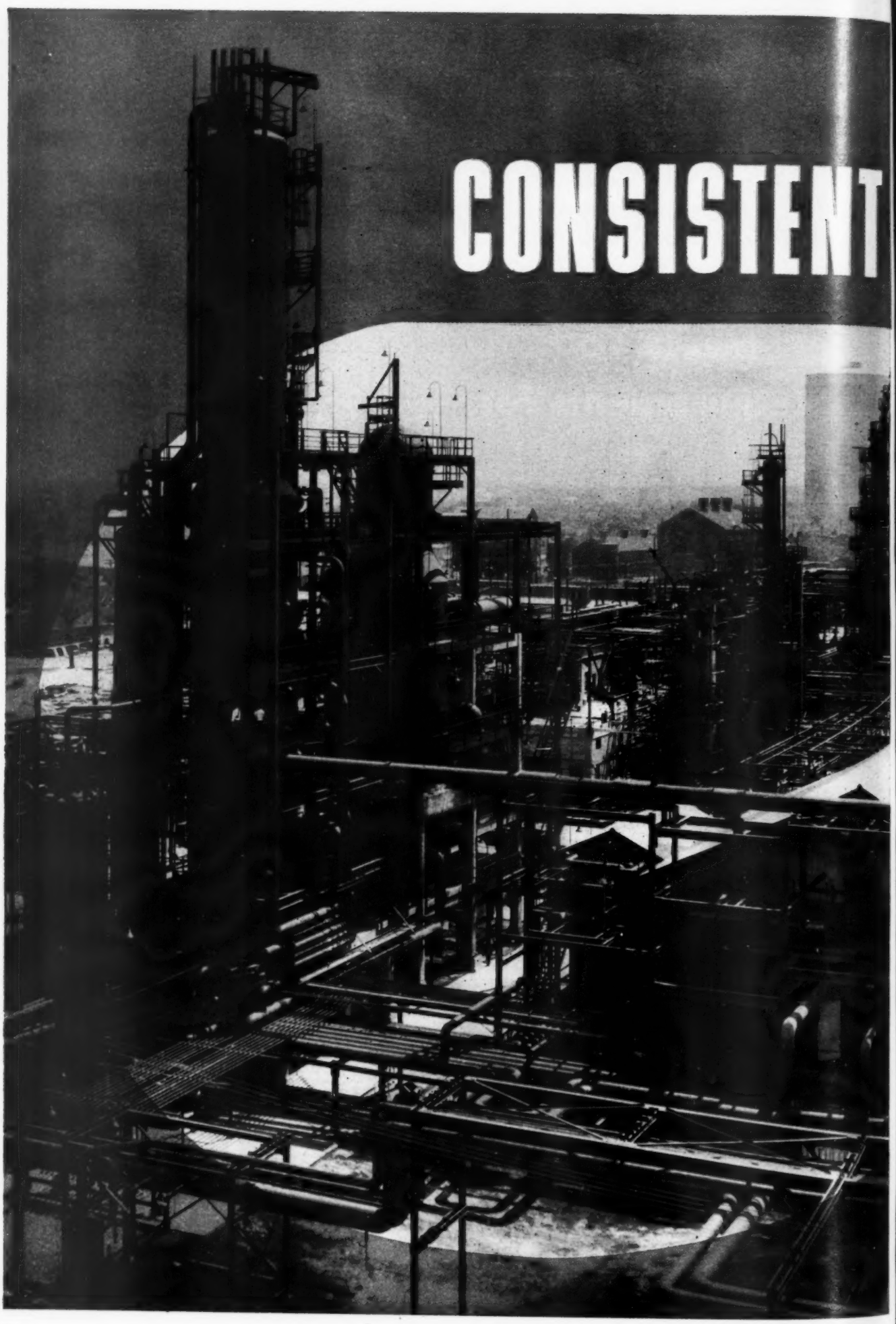
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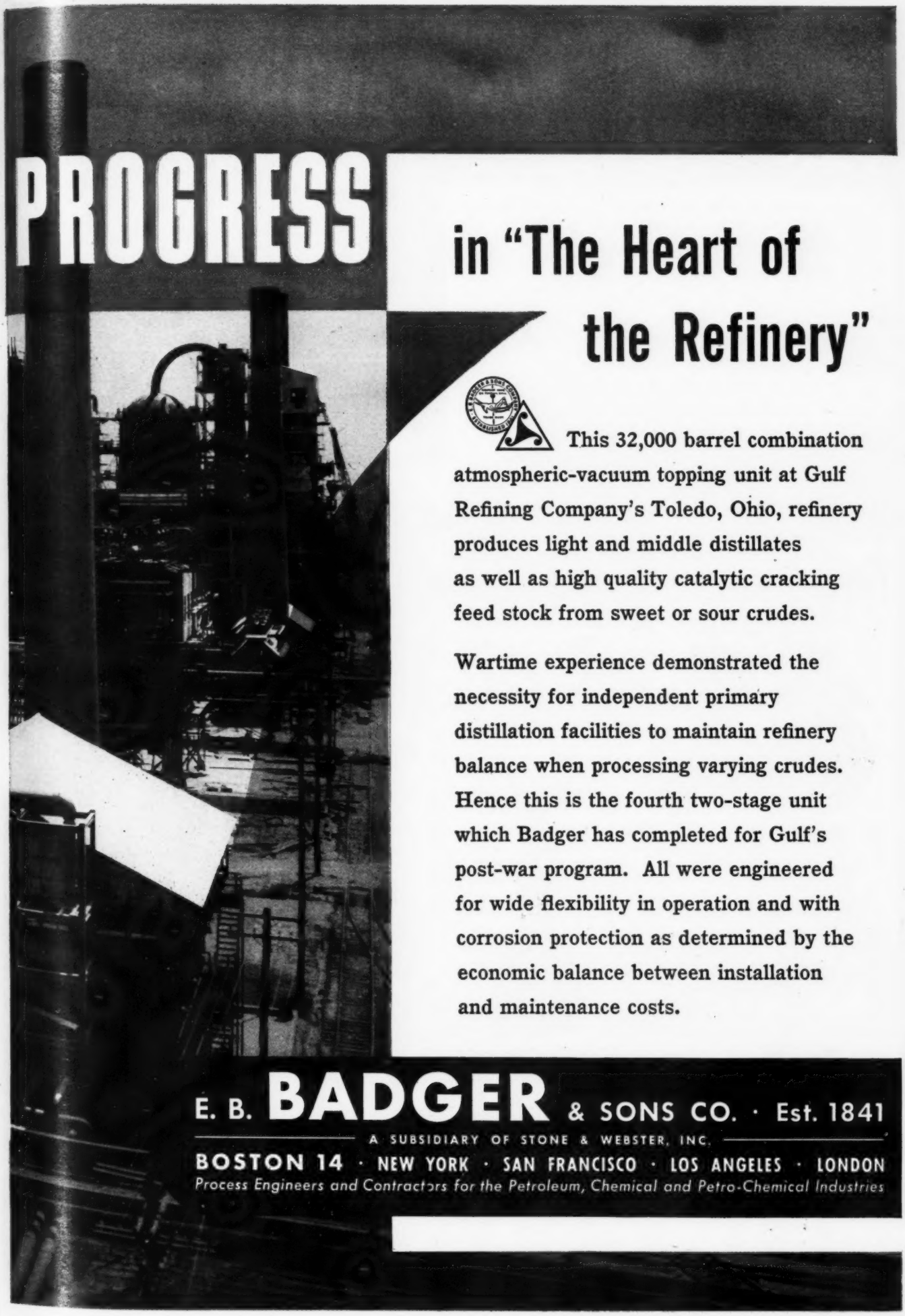

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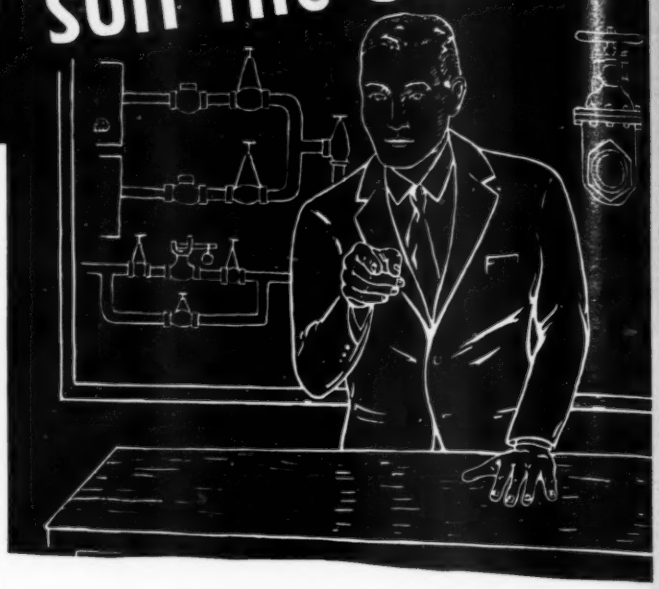

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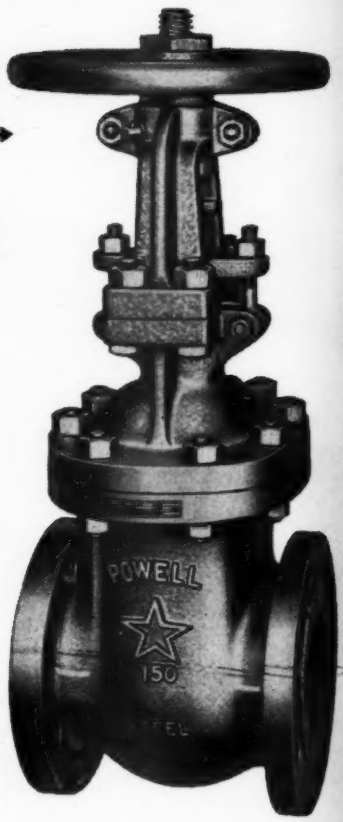

Fig. 1503—Class 150-pound Cast Steel Gate Valve with flanged ends, bolted flanged yoke, outside screw rising stem, tapered solid wedge. →

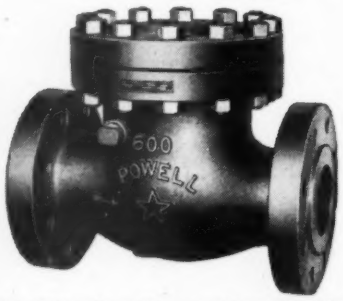

Fig. 6061—Class 600-pound Cast Steel Swing Check Valve with flanged ends and bolted cap. Disc has ample lift to permit full, straight-way, unobstructed flow through valve body.

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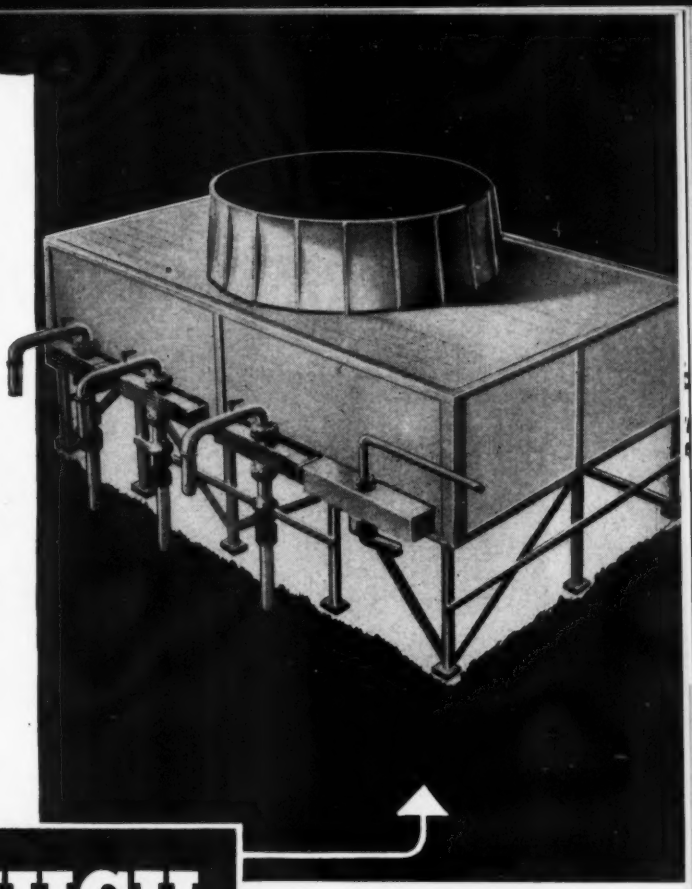

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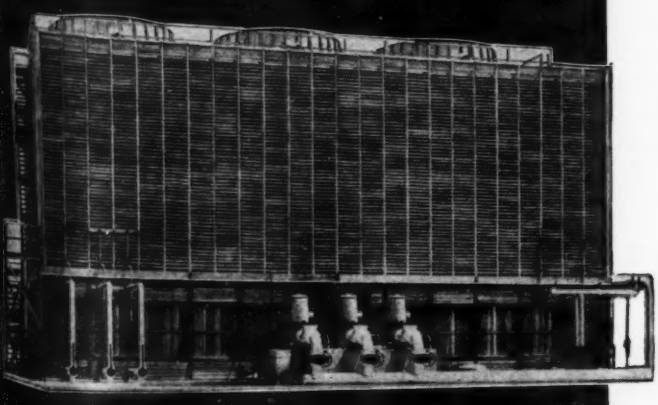

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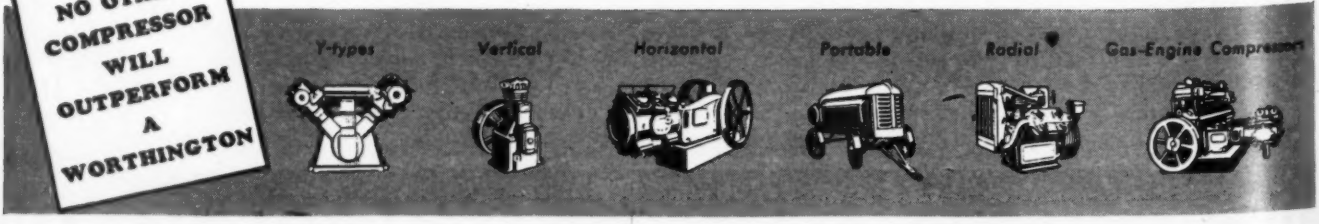

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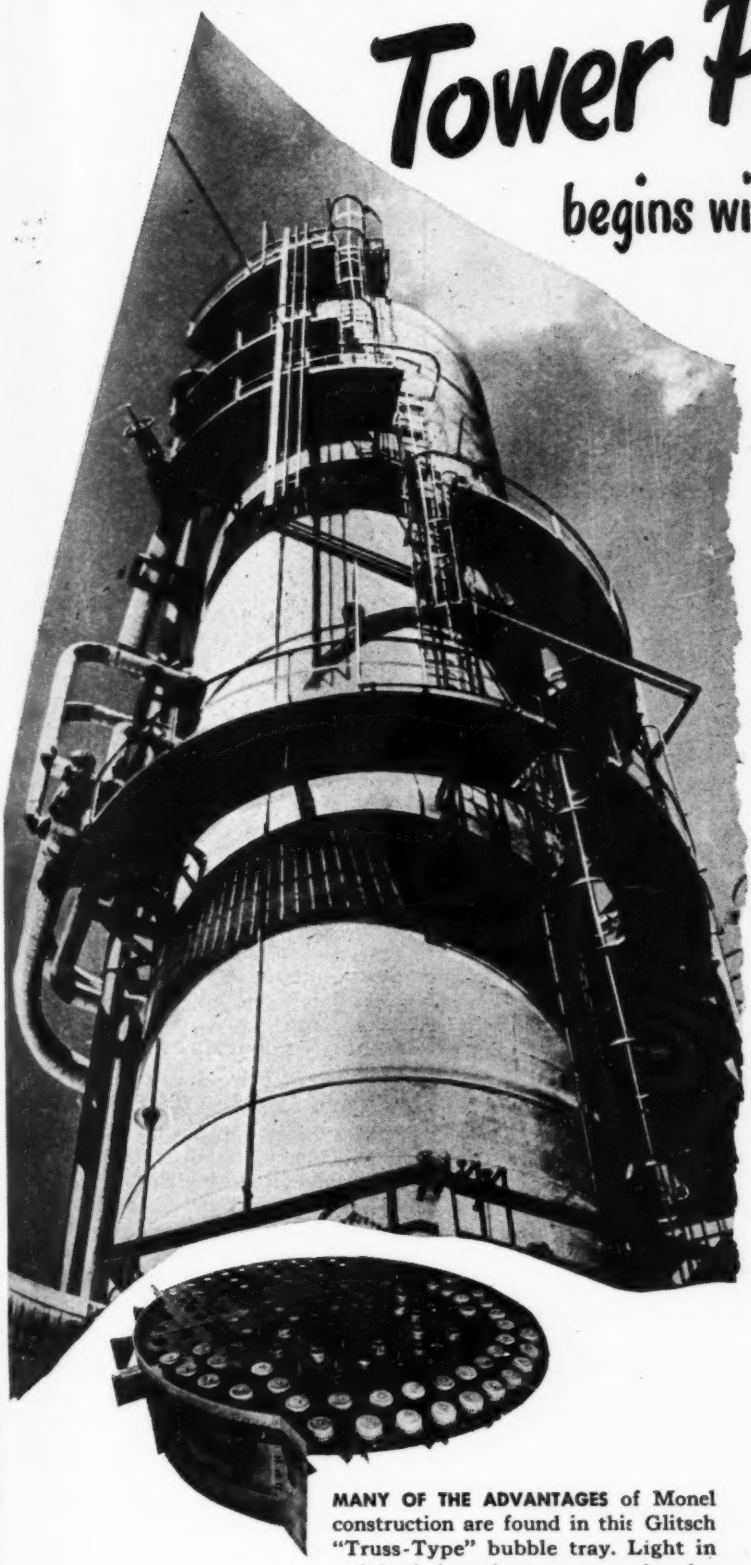
Tower Protection begins with Monel!



MANY OF THE ADVANTAGES of Monel construction are found in this Glitsch "Truss-Type" bubble tray. Light in weight, it is easier to erect and maintain. Monel's ductility eliminates breakage during installation and cleaning... Smooth, corrosion-resistant Monel surfaces increase tower efficiency, reduce coking hazards. And Monel caps and trays, if distorted by explosion, can be readily straightened and restored to service... *This photo used through courtesy of the fabricator, Fritz W. Glitsch & Sons, Dallas, Tex.*

Design engineers seldom know, these days, what the next crude will be like.

Today sweet—tomorrow sour. Or maybe a mixture of both. That's why top sections of fractionating towers need *plenty* of protection against corrosion.

And they get this protection from MONEL*. That has been proved time and again in every refining center.

Just recently, for example, The M. W. Kellogg Company, refinery and chemical engineers of Jersey City, New Jersey, designed a large refinery for charging a sour crude containing in the neighborhood of 2% sulfur. Kellogg knew from past experience that most commercial metals used in the top sections of the fractionating vessels would pit due to corrosive action by sulfur and salt compounds in condensed water vapor.

Consequently Kellogg engineers recommended Monel-lined nozzles for refluxing in top tower sections for temperatures of 400°F. or below. Monel does not pit under these conditions, and Kellogg knew it would display satisfactory resistance to predicted corrosion in the upper tower sections where temperatures below the dew-point are encountered.

Monel, as a matter of fact, is highly resistant to sulfur attack at temperatures up to 500° F. It resists corrosion by sulfuric acid, dilute hydrochloric acid, brines, sour crudes, caustics and chlorinated solvents. Its high strength and low corrosion rate make possible the use of thin, lightweight sections that save you money in both material cost and tower design.

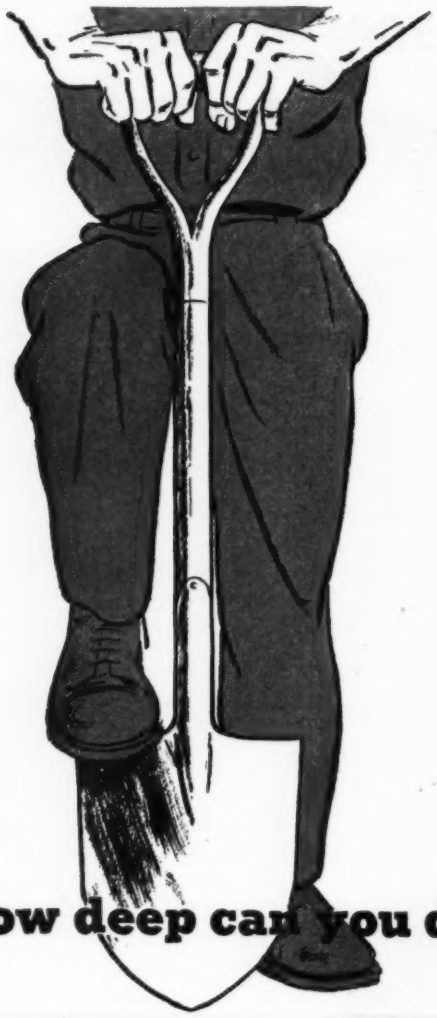
Before you choose a metal for top tower sections, be sure to investigate the advantages of using Monel. Write us for information and technical data now, so you'll have all the facts on hand when you need them.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

*Reg. U. S. Pat. Off.

EMBLEM OF SERVICE
INCO
TRADE MARK

MONEL...for minimum maintenance and replacement



How deep can you dig?

How far can you go in searching out an economical, positive solution to every refining problem? Can you afford, in terms of time and manpower, to get *all* the facts in every case . . . even when you are faced with several major problems at one time?

UOP

American Liberty Adds 10% to Gasoline Yield

By A. C. Johnson

Assistant Superintendent
American Liberty Oil Company
Mount Pleasant Refinery

AN INCREASE of about 10 percent in the overall gasoline production of our Mount Pleasant refinery has been realized without running additional crude by the installation of a non-selective catalytic polymerization plant. This unit utilizes UOP solid phosphoric acid polymerization catalyst for converting the propylenes and butylenes in the total cracking plant gas to hydrocarbons boiling in the gasoline range.

A. C. Johnson

A poly plant was first planned in 1941, but consideration was dropped during the war when practically all of our output was directed to the manufacture of fire bombs.

Because of vastly improved markets and the need for higher octane numbers, the project was revived in 1946 and Universal Oil Products Co. was asked to make a survey. As a result, UOP was called upon for all design and processing work, while American Liberty engineers conducted all architectural and layout work with UOP acting as consultant. All new vessels except the catalyst case and deethanizer tower were fabricated by the refinery with existing equipment being used wherever possible.

Design Capacity 2,160,000 cu. ft.

The design capacity of the poly unit is 2,160,000 cu. ft. of fresh cracked gas per day representing the total gas produced by the UOP thermal cracker. The quantity of polymer gasoline produced depends upon the amount of gas available for processing, and this in turn, depends upon the operating schedule of the cracking plant. At design capacity, the poly unit will produce 235 b/d of 10 pound polymer gasoline. During the past year, however, it has been advisable to operate the cracking plant for maximum throughput of gas oil rather than for maximum yield which has limited the poly yield to an average of 170 b/d.

Shut down on April 4 of this year, after its first run of 195 days actual on stream time, the poly unit showed a total output of 1,263,765 gal. or 81 gal. per pound of catalyst.

The polymer gasoline produced has a clear Motor Method and a clear Research Method octane number of 82.5 and 97 respectively with blending values substantially higher. The high octane blending value, both motor and research, makes this product very valu-

able in raising the overall level of the refinery's gasoline. By blending with cracked gasoline and selected straight run materials, the octane rating of premium gasoline can be raised two octane numbers, or a given octane reached with approximately half the lead formerly required.

Gas from the cracking plant absorber is compressed in the low stage of the compressor, and together with the high pressure gas from the cracking plant stabilizer, is sent to the treating section operating at 150 psi. Having about 1,200 grains of H_2S per 100 cu. ft. and fairly high mercaptan content, the gas first enters the Girbitol unit where H_2S is removed down to 25 grains. In the H_2S scrubber the last traces are removed by caustic. Mercaptans are extracted in a regenerative caustic system.

The sweet gases are then compressed in the high stage to 500 psi, and heated to 380° F. by first exchanging heat with catalyst tower effluent and then through a heater using hot oil from the cracking unit as a heating medium. The hot gas enters the top of the catalyst chamber where contact is made with the catalyst, which is arranged in five beds with a total charge of 15,000 pounds. Proper hydration of the catalyst is controlled by the addition of water and the reaction temperature of each bed is controlled by using liquid propane as a quench.

Operating Data

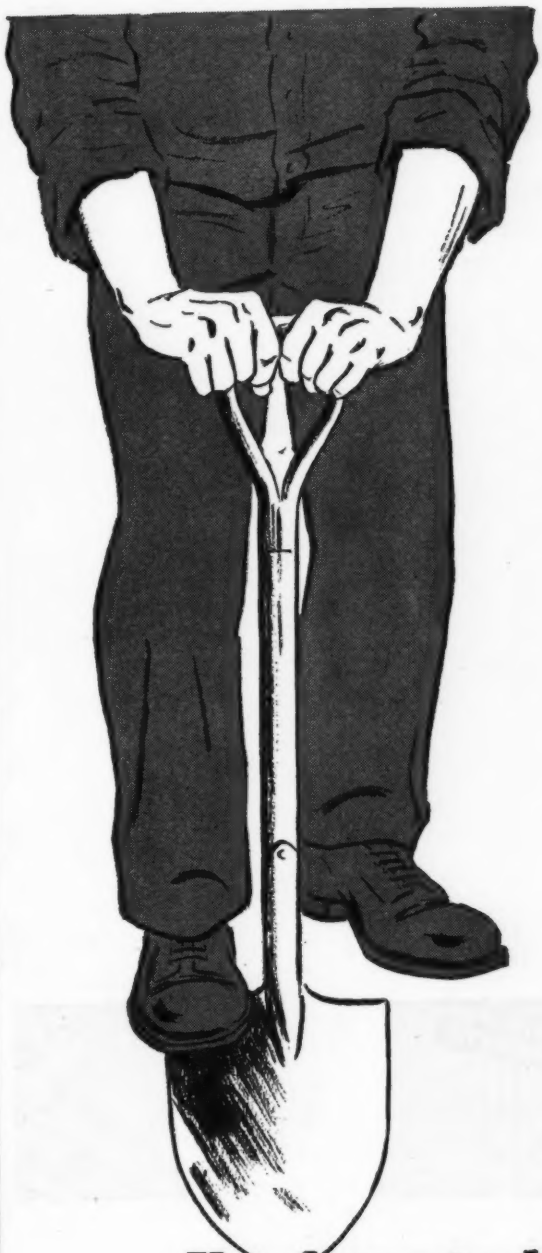
Operating data for the catalyst tower is as follows:

Pressure, psi	450
Temperature, Gas in, °F.	380
Temperature, 1st Bed, °F.	410
Temperature, 2nd Bed, °F.	420
Temperature, 3rd Bed, °F.	425
Temperature, 4th Bed, °F.	430
Temperature, 5th Bed, °F.	435

After the polymerizing action of the catalyst, the effluent from the catalyst chamber is cooled and gas is removed from top of the catalyst tower effluent receiver. This gas goes to the poly absorber where recoverable light ends are picked up and returned to the cracking plant fractionator. The liquid from the receiver is then charged to the deethanizer.

With adequate cooling and subsequent low deethanizer receiver temperature, maximum propane recovery is possible. A small amount of propane, together with the ethane and lighter gases, is taken overhead to fuel, and bottoms are charged to the depropanizer. The depropanizer, operating at 275 psi produces specification propane overhead, the bottom being charged to the debutanizer. From the bottom of this vessel poly gasoline at specified Reid vapor pressure is removed with all excess butane going overhead to storage.

Today the American Liberty Mount Pleasant Refinery has a crude capacity of 13,000 barrels, thermal cracking capacity of 4,000 barrels, and facilities for the manufacture of asphalt and special naphthas, as well as the new poly unit.



You have to dig deep

Successful refining demands that you dig deep for facts and solutions, regardless of the size of your staff or the time available. That's why refiners depend on Universal service. It's their assurance of help in finding the answers to technical, physical and economic problems . . . especially when they need help in a hurry.

UNIVERSAL OIL PRODUCTS COMPANY

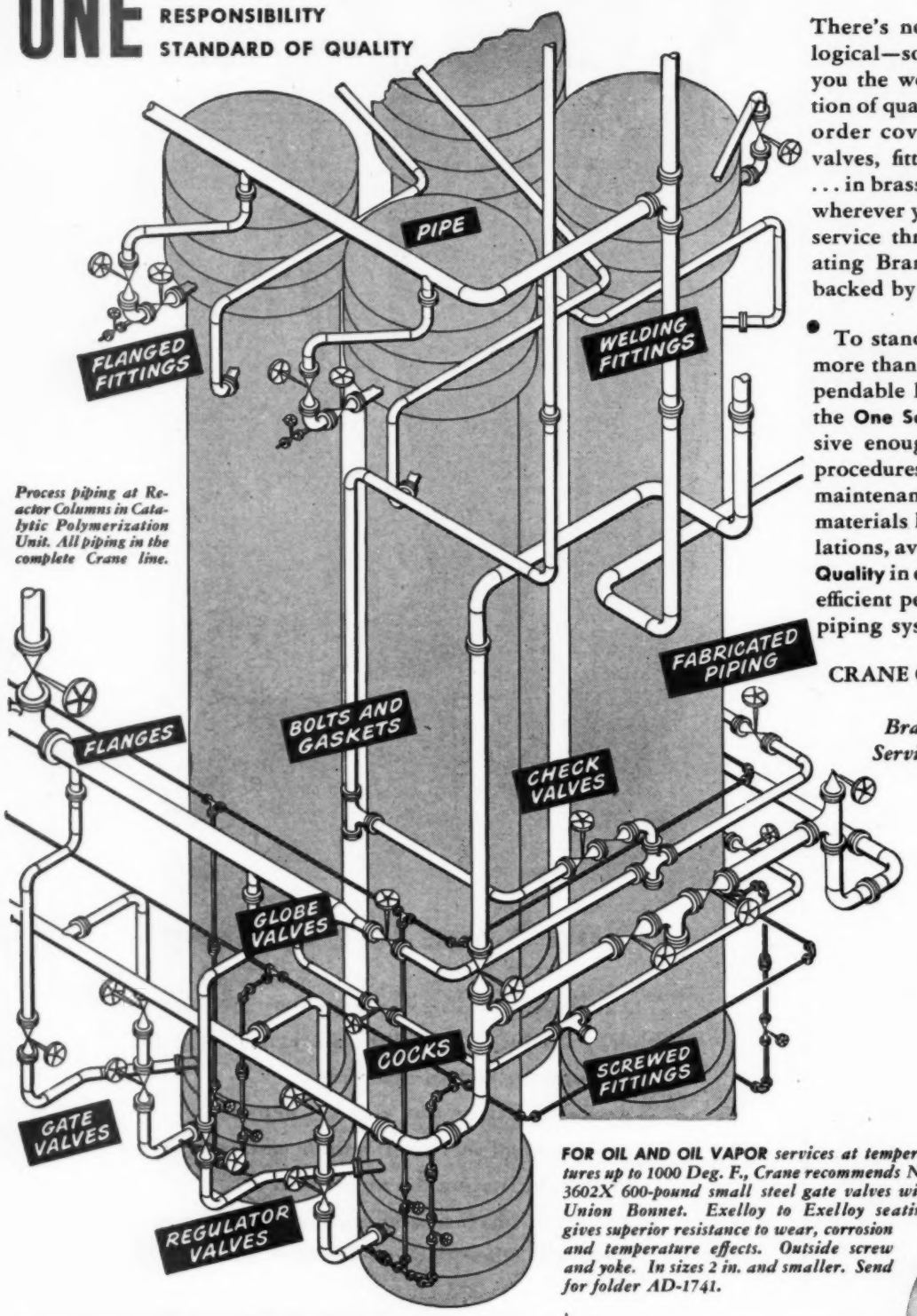
UOP

General Offices: 310 S. MICHIGAN AVE., CHICAGO 4, ILLINOIS, U.S.A.
LABORATORIES: RIVERSIDE, ILLINOIS

Universal Service Protects Your Refinery

To standardize most profitably ...Get everything from CRANE

ONE SOURCE OF SUPPLY
RESPONSIBILITY
STANDARD OF QUALITY

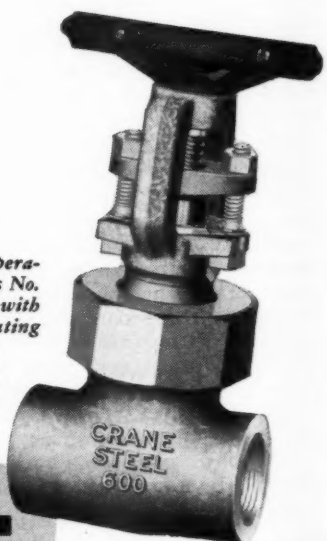


Process piping at Reactor Columns in Catalytic Polymerization Unit. All piping in the complete Crane line.

There's no more advantageous—or logical—source to rely on. Crane offers you the world's most complete selection of quality piping equipment. One order covers whatever you need—valves, fittings, pipe and accessories ... in brass, iron, steel and alloys. And wherever you are, you're sure of better service through well-stocked cooperating Branches and Wholesalers ... backed by large factory stocks.

• To standardize on Crane gives you more than complete selection plus dependable local distribution. Crane is the **One Source of Supply** comprehensive enough to simplify your piping procedures, from design to erection to maintenance. **One Responsibility** for materials helps to assure better installations, avoids needless delays. **Highest Quality** in every item from Crane makes efficient performance throughout your piping system a foregone conclusion.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas



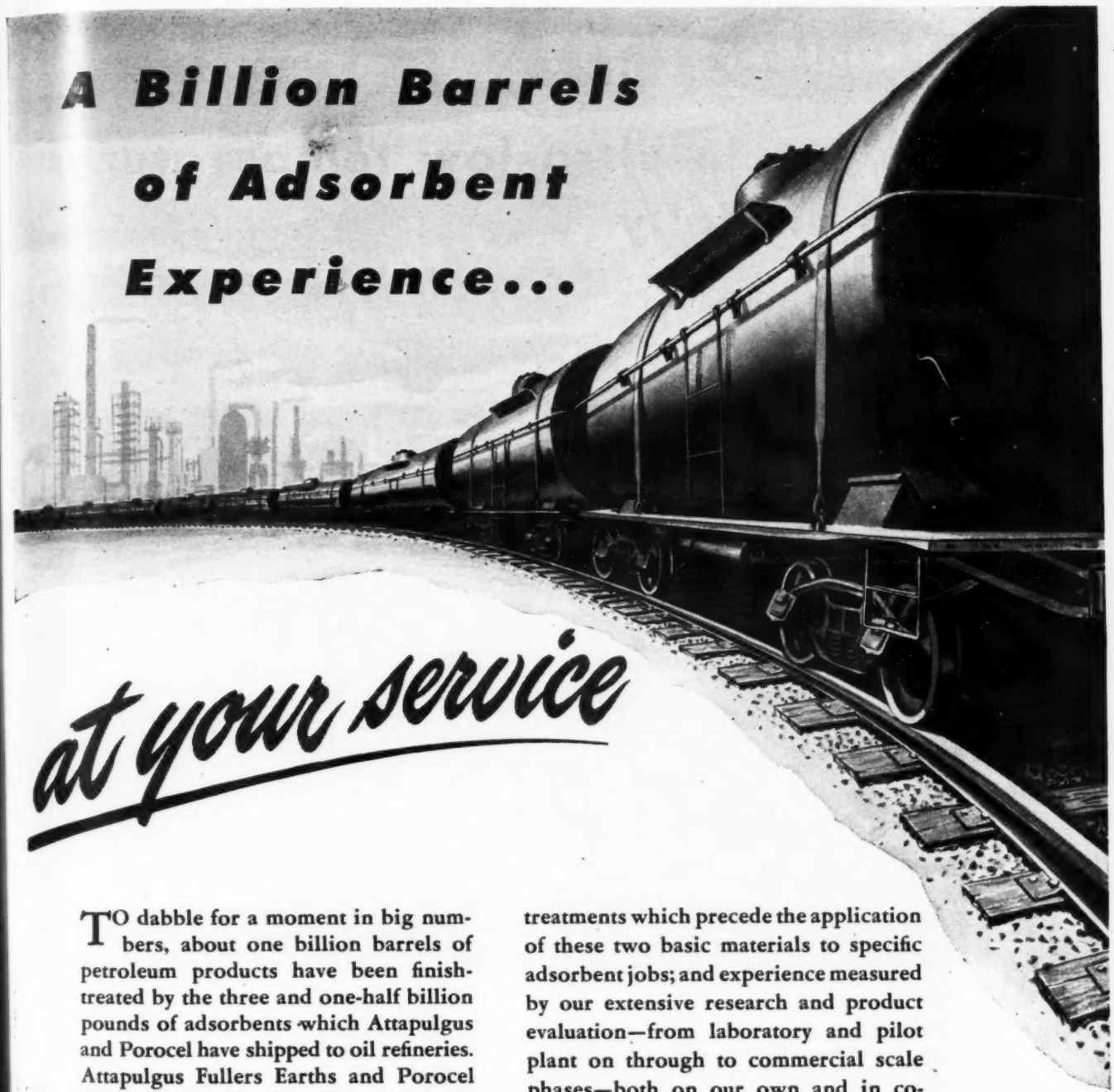
FOR OIL AND OIL VAPOR *services at temperatures up to 1000 Deg. F., Crane recommends No. 3602X 600-pound small steel gate valves with Union Bonnet. Exelloy to Exelloy seating gives superior resistance to wear, corrosion and temperature effects. Outside screw and yoke. In sizes 2 in. and smaller. Send for folder AD-1741.*

EVERYTHING FROM ...

VALVES • FITTINGS
PIPE • PLUMBING
AND HEATING

CRANE

FOR EVERY PIPING SYSTEM



TO dabble for a moment in big numbers, about one billion barrels of petroleum products have been finish-treated by the three and one-half billion pounds of adsorbents which Attapulgus and Porocel have shipped to oil refineries. Attapulgus Fullers Earths and Porocel Activated Bauxites have become recognized standards in the removal or reduction of odors, colors, tastes, moisture, acids, sulfur, fluorides and unsaturates, and for solid catalyst purposes. And in this wide range of services, finished value was gained in a long list of petroleum cuts—from the lightest distillates to the heaviest lubes and waxes.

This all adds up to a lot of adsorbent experience—experience with the many treatments which precede the application of these two basic materials to specific adsorbent jobs; and experience measured by our extensive research and product evaluation—from laboratory and pilot plant on through to commercial scale phases—both on our own and in co-operation with our customers.

So there's great merit to the suggestion that it pays to consult Attapulgus and Porocel. In your own plans to improve products or expand output, perhaps our one billion barrels of adsorbent experience can be of real help to you in selecting the right adsorbent and the right conditions. Our laboratory and process staff are at your service, without obligation.

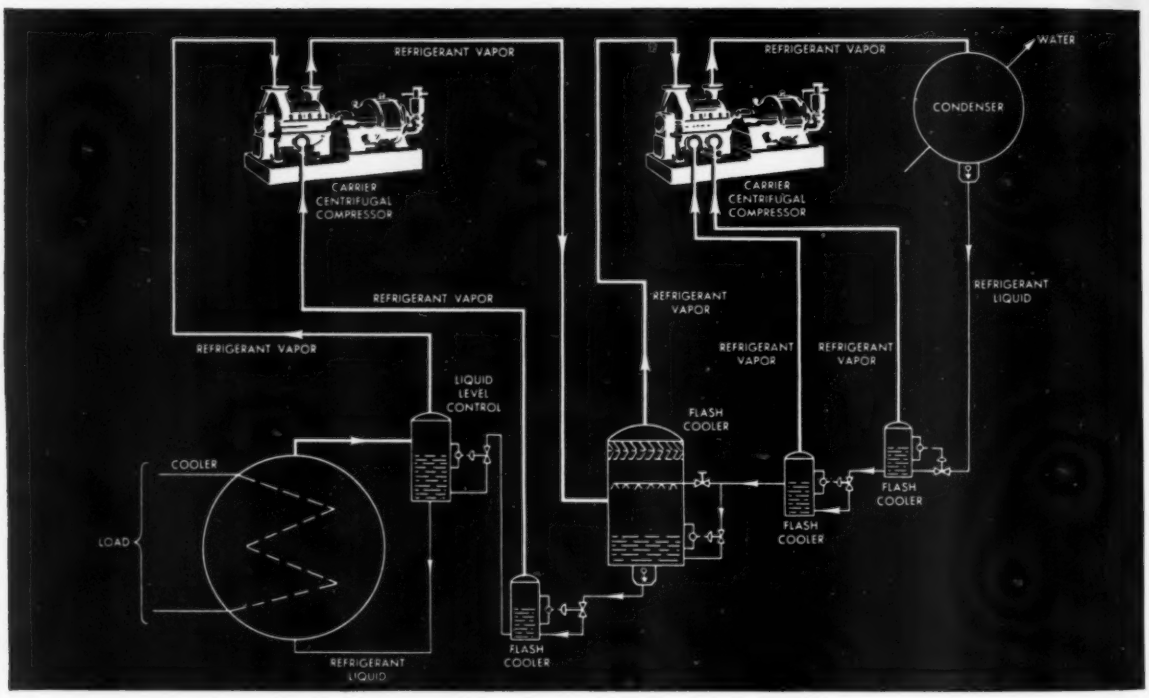
ATTAPULGUS CLAY COMPANY *Fullers Earth* • **POROCEL CORPORATION** *Activated Bauxites*

Dept. D, 210 West Washington Square, Philadelphia 5, Pa.

PROBLEM:

How to attain ultra-low temperatures economically

SOLUTION:



THIS DIAGRAM shows the use of Carrier Centrifugal Compressors staged in a low-temperature refrigerating cycle employing hydrocarbons or halogenated hydrocarbons as refrigerants. This application of Carrier Centrifugals has been proved exceptionally economical and efficient in many leading plants.

The design of these compact, dependable units provides many advantages, among them:

1. No expansion valves or reciprocating mechanism to create problems at ultra-low temperatures.
2. Because the bearings are located outside the gas passages, difficulties with lubrication are at a minimum. This same design feature also improves efficiency by virtually eliminating oil fouling of heat-exchanger surfaces.
3. Carrier Centrifugals require no expensive foundations and can be operated without housing.
4. Rotative design assures low operating and maintenance cost.
5. The installed cost is low and the units can be easily and quickly placed in service.

Besides straight series staging, Carrier Centrifugal Compressors are used in cycles involving a cascade arrangement where full advantage is made of the thermodynamic properties of two refrigerants. This results in reduced exchanger surface and higher efficiencies.

Designed and built in the same tradition of leadership that developed rotative refrigeration more than a quarter of a century ago, Carrier Centrifugal Compressors give long life with low-cost, efficient service. As a result of their proved performance, more of these Carrier-designed machines have been sold than any other kind. They are now available for prompt delivery. For full facts, call your nearest Carrier representative. Carrier Corporation, Syracuse, New York.

Carrier CENTRIFUGAL COMPRESSORS • REFRIGERATING EQUIPMENT

L7 A Husky Steel

for Low-Temperature Bolting

When refinery engineers encounter bolting conditions with temperatures as low as –150 F, they can count on Bethlehem fastenings made from Bolting Grade L7. For at this low temperature, L7 offers minimum impact strength of 15 ft-lbs. It's a husky through and through—a heat-treated alloy steel which has been specially developed for the manufacture of studs and bolts for service at sub-zero temperatures. It conforms to ASTM Specification A320—48T, and fulfills the following chemical and tensile requirements:

L7—CHEMICAL REQUIREMENTS

	RANGE	Check Variation Over or Under *
Carbon, pct	0.38 to 0.45	0.02
Manganese, pct	0.75 to 1.00	0.04
Phosphorus, pct	0.040	0.005 over
Sulphur, pct	0.040	0.005 over
Silicon, pct	0.20 to 0.35	0.02
Chromium, pct	0.80 to 1.10	0.05
Molybdenum, pct	0.15 to 0.25	0.02

**Unless otherwise specified, separate determinations may vary from the specified ranges, except that elements in any heat must not vary both above and below the specified range.*

L7—TENSILE REQUIREMENTS

Diam, In.	Tensile Strength min psi	Yield Point min psi	Elongation in 2 in. min pct	Reduction of area min pct
2½ and under	125,000	105,000	16	50
Over 2½ to 4 incl.	105,000	80,000	20	50

Grade L7 fastenings can be obtained in short order, because the steel from which they are made is a stock item with Bethlehem. They are recommended for use with the Bethlehem Grade 4 carbon-molybdenum nut, also carried in stock. Bethlehem also produces a wide range of steels for use in high-temperature bolting.

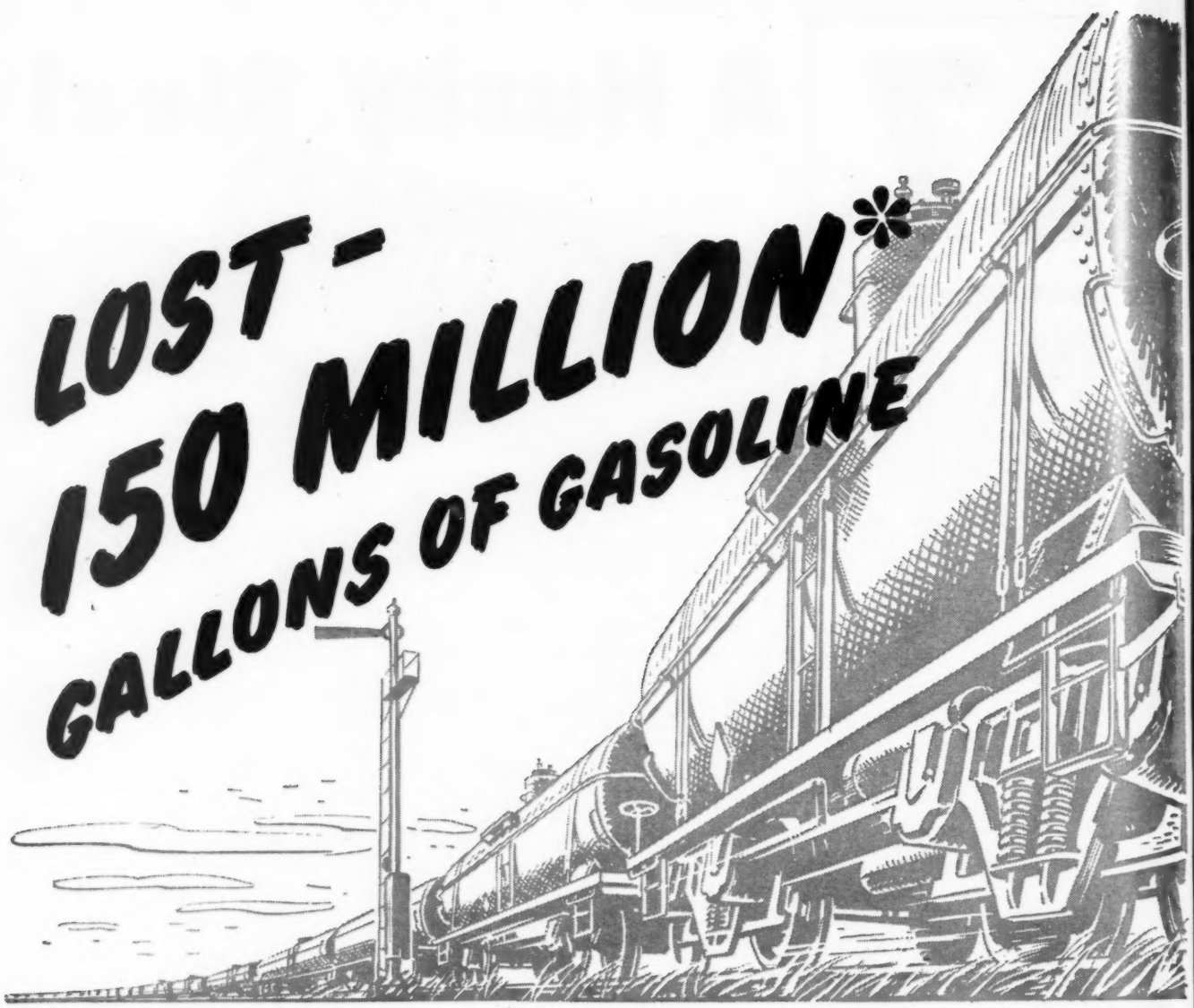
Along with its fully-equipped fastenings plant at Lebanon, Pa., Bethlehem has an engineering staff which is available to work with you in solving virtually any low-temperature or high-temperature fastenings problem that comes along. So put your fastenings needs up to us . . . today, tomorrow, any time.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

Bethlehem supplies every type of Fastening

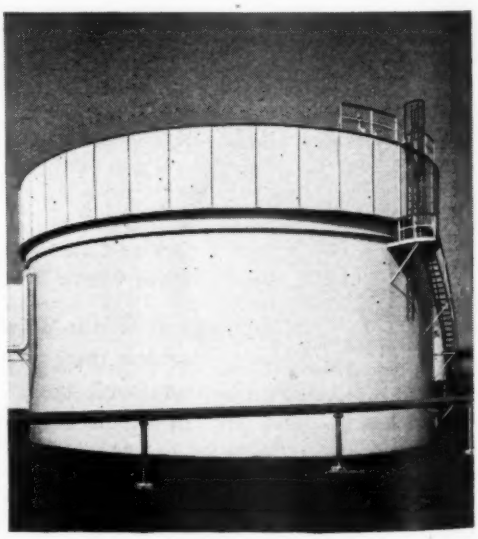


ENOUGH gasoline is lost by evaporation each year in this country to fill a tank car train 150 miles long. Much of this waste could be avoided through the use of Graver conservation equipment.

First and foremost in the battle for conservation is the Graver Expansion Roof Tank. It *ends evaporation losses* . . . provides protection of multiple tank installations through manifolding . . . maintains quality throughout the storage period. It also adds the advantages of *safety* — reduced fire hazard . . . *simplicity* — no maintenance problem . . . and *permanence* — no parts to wear.

With every one, from Congress to consumer, worried over dwindling oil reserves and so much gasoline vanishing into thin air, it's time to talk it over with Graver. Ask Graver engineers to analyze your storage problems and show you how the Expansion Roof stops vapor losses.

**Estimated*



GRAVER

FABRICATED PLATE DIVISION

GRAVER TANK & MFG. CO., INC.

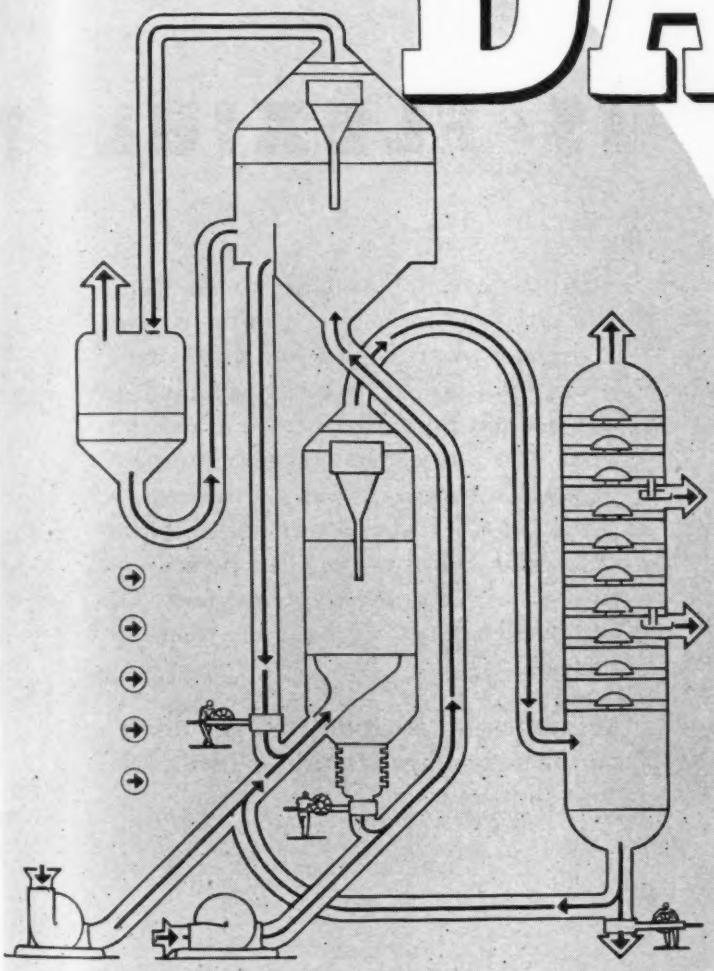
EAST CHICAGO, INDIANA

NEW YORK • PHILADELPHIA • CHICAGO • CATASAUQUA, PA. • HOUSTON • SAND SPRINGS, OKLA.

Leading refiners specify

DA-1®

FLUID SYNTHETIC CRACKING CATALYST



1 FACILITIES—Plants in Baltimore and Cincinnati produce a major portion of the fluid synthetic cracking catalyst used by the petroleum industry.

2 EXPERIENCE—Davison built and continues to operate the first plant producing fluid synthetic cracking catalyst for the industry.

3 SERVICE—Davison offers complete laboratory and testing facilities for catalyst evaluation . . .

Consult Davison for the development of special catalysts in fluidized or pelleted form for your particular process.

Write for Information and Specifications

Davison's close laboratory control of production maintains a high standard of particle uniformity to assure maximum catalyst utilization. Increasing numbers of the world's leading refineries are specifying DA-1 (Synthetic Silica Alumina) Fluid Cracking Catalyst . . . available in three grades . . .

F-1, Fine Grind; C-1, Intermediate Grind
C-2, Coarse Grind

THE DAVISON CHEMICAL CORPORATION

Progress through Chemistry

BALTIMORE-3, MD.

HOW *Flexible* IS FLEXIBLE?

We claim "flexibility" to be an important feature of the Republic Pneumatic Transmitter. Its importance to you, however, depends largely upon what we mean by "flexible."

To be easily adaptable to a wide variety of metering applications under varying conditions is our interpretation of "flexibility." The Republic Pneumatic Transmitter is an extremely accurate metering device which, through the simple interchange of a few standard parts, can be adapted to the measurement of flow, pressure, level or density of a wide variety of fluids.

Furthermore, it has been so designed that by making a few minor adjustments or substituting a few small parts, it's operation can be easily changed to any desired range between a minimum of 0 -0.6" of water to a maximum of 0 -704" of water. Range supression (up to 80%), reversal or compounding (plus and minus scales) can be accomplished in the same simple manner. All of these changes can be easily made in the field.

We repeat—"flexibility" is an important feature of the Republic Pneumatic Transmitter.

★ ★ ★

The Republic Transmitter is a pneumatic metering device. It employs the force-balance principle to convert process variables such as flow, liquid level, pressure or liquid density, into air pressures which vary proportionally with the process variables.

These air pressures become direct measurements and can be conducted to reading instruments or used as the measuring impulse for the actuation of an automatic controller.

For complete details write for Data Book No. 1001

REPUBLIC FLOW METERS CO.
2240 Diversey Parkway, Chicago 47, Illinois

a complete petroleum refinery

capacity: 110,000 bbls/day

Foster Wheeler will build this complete refinery—the largest in Europe—for Anglo-American Oil Co. Ltd., affiliate of Standard Oil Company (New Jersey).

In collaboration with the Engineering Division of the Standard Oil Development Company, Foster Wheeler will provide mechanical design and engineering and will construct 9 process units including a large Fluid Catalytic Cracking Unit.

With the exception of tankage, marine facilities and administration and laboratory buildings, Foster Wheeler will also erect all off-site facilities, including a complete steam plant.

This is an outstanding example of the comprehensive engineering and construction service offered by Foster Wheeler. It is available—anywhere in the world—for all types of petroleum processing units, complete petroleum refineries, and complete chemical plants.

FOSTER WHEELER CORPORATION
165 BROADWAY, NEW YORK, 6 NEW YORK

Foster Wheeler welcomes this opportunity to congratulate The American Petroleum Industry on its 90th Birthday.

(Colonel Edwin Drake brought in the nation's first commercial oil well on August 27th, 1859, – 90 years ago this month)

FOSTER WHEELER CORPORATION

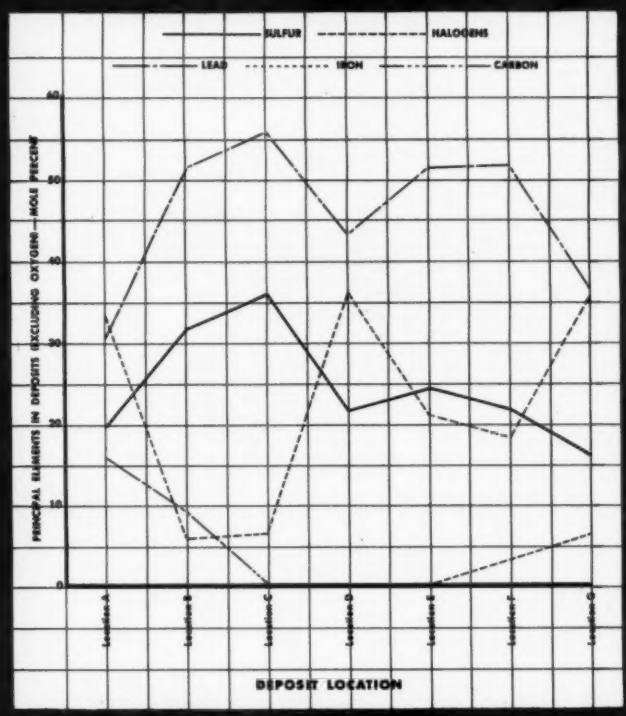
165 BROADWAY, NEW YORK 6, NEW YORK

A Complete Engineering and Construction Service–Anywhere in the World

nvestigating Engine Deposits for their effect n Fuel Performance

l liquid fuels burned in internal combustion engines pro- ce combustion chamber deposits, the composition of which ll vary with the hydrocarbon composition of the fuel, the type lubricating oil and the presence or absence of tetraethyl lead. vestigation into the composition of deposits from leaded solines has shown that in addition to simple compounds ey consist of complex mixtures of compounds. Among ose definitely identified to date are the eleven listed below. The most modern X-ray diffraction apparatus and other ecialized equipment is used in the analysis of deposits, iden- ying the different compounds formed under various oper- ng conditions and at various locations within the engine. This is research upon specific and recognized problems orking toward answers which will benefit the entire industry.

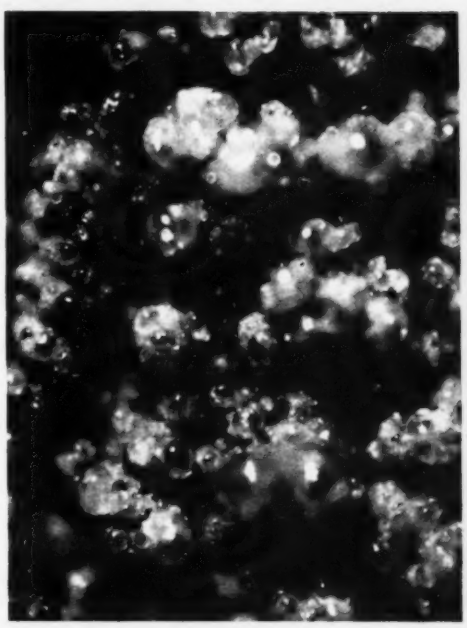
COMBUSTION CHAMBER OF LABORATORY TEST ENGINE



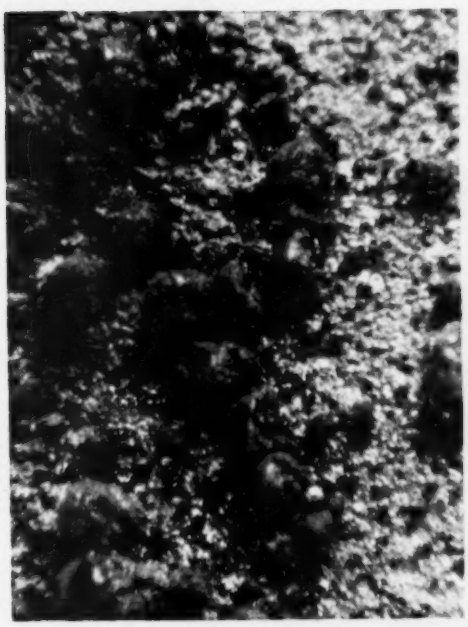
EPOSIT COMPOSITION

he following lead compounds are ome that have been identified to date combustion chamber deposits in ad- ition to those contributed by the base el and lubricating oils.

- PbO
- $PbSO_4$
- $PbSO_4$. PbO
- $PbSO_4$. 2PbO
- $PbSO_4$. 4PbO
- $PbBr_2$
- $PbCl_2$
- $PbBr_2$. $PbCl_2$
- $PbBr_2$. 2PbO
- $PbCl_2$. 2PbO
- $PbCl_2$. PbO



Photomicrograph of deposit from piston top.



Photomicrograph of deposit from intake valve stem.

DU PONT
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Better Things for Better Living . . . *Through Chemistry*

MAKE DU PONT THE SOURCE FOR ALL OF YOUR GASOLINE ADDITIVES . . .

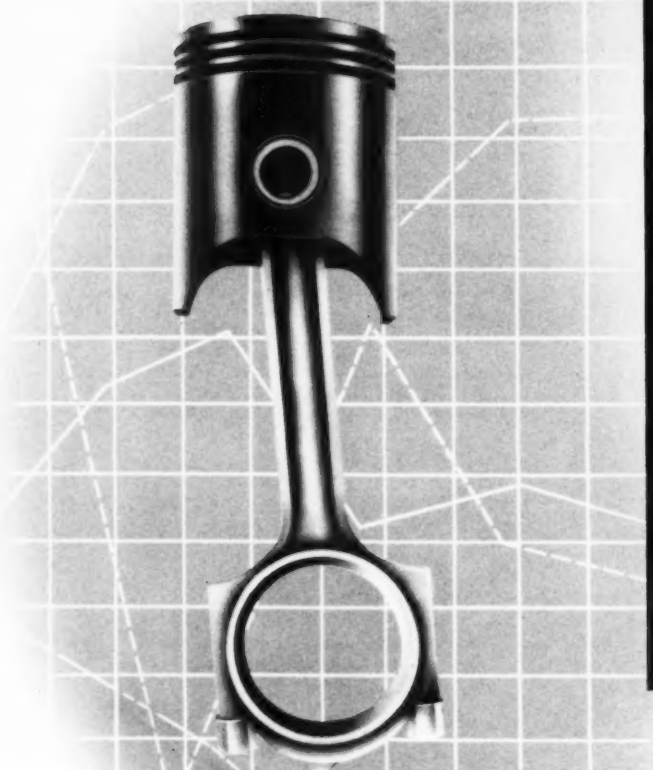
Tetraethyl Lead Compounds
Motor Mix—Aviation Mix
Antioxidants
Metal Deactivator—Dyes

E. I. DU PONT DE NEMOURS & COMPANY (INC.)
PETROLEUM CHEMICALS DIVISION
Wilmington 98, Delaware

District Laboratories: Wilmington, Del. · Chicago, Ill. · Tulsa, Okla. · Houston, Texas · El Monte, Calif.

District Offices: Wilmington, Del. · Chicago, Ill. · Tulsa, Okla. · Houston, Texas · Los Angeles, Calif.

DUPONT TETRAETHYL LEAD COMPOUND



Piston top deposit, heavy duty, constant speed conditions.

Exhaust valve head deposit, heavy duty, constant speed conditions.

DuPont Research

at Work on the Chemical Nature of Engine Deposits

It has long been recognized that combustion chamber deposits greatly affect fuel performance . . . but little has been known about the relationship between deposit composition and effect on combustion.

As a part of its long-range Petroleum Chemicals research program, Du Pont is making an intensive study of the chemical nature of these deposits, and their effect on fuel performance. By a better and more complete understanding of the over-all deposit problem it is hoped that better scavenging agents or other additives may be developed which will help in the production of improved fuels... today and in the future.

DU PONT
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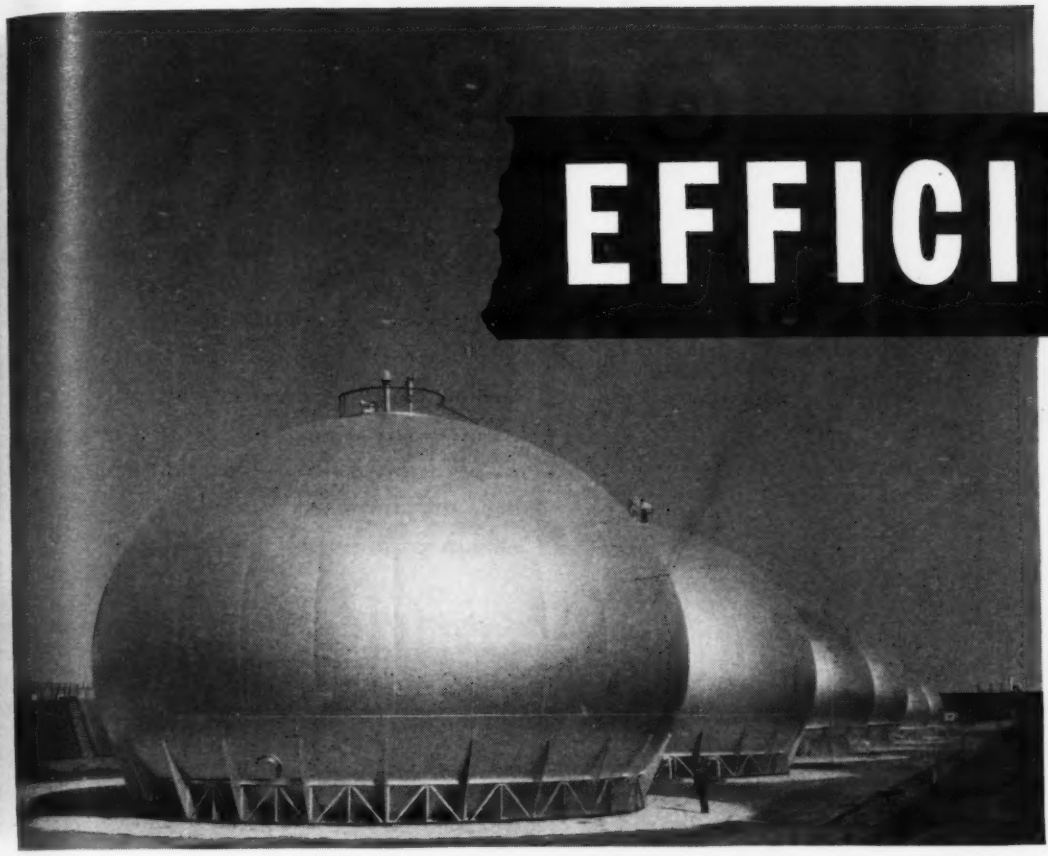
Better Things for Better Living . . . *Through Chemistry*



JUST AS EFFICIENT AS THEY LOOK

HORTONSPHEROIDS

The business-like tanks shown above are Hortonspheroids—containers designed to provide maximum protection against evaporation loss for volatile liquids that require storage under pressures from 2½ to 100 lbs. per sq. in. This includes all grades of motor fuel, natural gasolines, butanes, and refinery charging stocks.

You can count on the Hortonspheroid for dependable, low cost per barrel storage, year after year, without costly maintenance. Plain Hortonspheroids are commonly built in capacities from 2,000 to 40,000 bbls. while Noded Hortonspheroids cover a range of sizes from 20,000 to 120,000 bbls. Using the equation at the right, you can determine the design pressure in the range available—from 2½ to 100 lbs. per sq. in.—that is required to handle your products. Write our nearest office about your oil storage requirements. We'll recommend the proper types of Horton tanks for the job.

The view above shows 6 plain-type Hortonspheroids at a West Coast refinery. The 30,000-bbl. units in the foreground are designed for storage pressures of 15 lbs. per sq. in., and the two 15,000-bbl. units at the far end are designed for pressures of 25 lbs. per sq in.

HOW TO DETERMINE THE WORKING PRESSURE OF A HORTONSPHEROID TO PREVENT STANDING STORAGE LOSSES

Required data: Vapor pressure of product, temperature variation of the liquid surface, temperature variation of the air-vapor space and the setting of the vacuum vent.

Required storage pressure

$$= P + \left[(V - p) \left(\frac{T + 460}{t + 460} \right) \right] - A$$

P = Vapor pressure of liquid at maximum surface temperature

p = Vapor pressure of liquid at minimum surface temperature

V = Absolute pressure in tank at which vacuum vent opens

T = Maximum average temperature of air-vapor mixture

t = Minimum average temperature of air-vapor mixture

A = Atmospheric pressure (14.7)

(All pressures are in lbs. per sq. in. and all temperatures in degrees Fahr.)

Note—The relations in the above formula hold true only when the vapor pressure of the liquid at minimum surface temperature is less than the absolute pressure in the Hortonspheroid at which the vacuum vent opens.

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PETROLEUM PROCESSING
AUGUST, 1949

ASTM to Establish Standards For Measuring, Analyzing Wastes

A STAFF REPORT
by the Editors of Petroleum Processing

RECOGNIZING the growing importance of the industrial waste problem, the American Society for Testing Materials has established a new group to study the subject and formulate standards for measuring, sampling, and analyzing wastes. In addition, the society last month held a round table discussion on "The Need for Standards for the Examination of Water-Borne Industrial Wastes," at its annual meeting in Atlantic City.

The newly formed group studying industrial wastes is the first organized ASTM activity in this field, and has been set up as Subcommittee VII on Water-Borne Industrial Wastes of ASTM's Committee D-19 on Industrial Waters. It was organized last October at a special meeting in Pittsburgh, and since then has been lining up committee members and detailing the scope of its activities. Chairman is L. Drew Betz, of W. H. and L. D. Betz, Philadelphia, a firm of chemical engineers and consultants on water problems.

Scope of the Work Defined

Scope of the new Subcommittee VII, according to the recent annual report of its parent Committee D-19, "comprises the preparation of standard methods for sampling water-borne industrial wastes, the preservation and analysis of samples, and the methods of reporting the results of such analyses." Its activities are limited to water-borne industrial wastes developed or produced within an industrial establishment.

Several members of the group emphasized that it is interested only in setting up standards for determining the "quantity and quality" of wastes being produced—and not in establishing any standards with respect to what constitutes pollution or how disposal should be effected.

"The present Federal and state activity in cleaning up streams and reducing pollution," one member explained, "is going to bring into the picture a lot of people not experienced with industrial wastes. What we want to do is to give them some standard tools with which to work, so that if a state health officer tells a company that it is discharging a waste with too high a suspended-solids content, everyone concerned will know exactly how that content was determined.

"Other agencies will have to establish the amount of suspended solids necessary to constitute pollution—but we hope to give them standard testing procedures so that both industry and the authorities will be talking about the same thing."

Four Sections Set Up

As presently set up, the work of Subcommittee VII is being carried out by four sections, as follows:

Section A on The Critical Constituents of Water-Borne Industrial Wastes, whose scope is the selection of a key determination on a specific waste by which it may be evaluated. The function of Section A is to prepare a list of the types of wastes produced by a given industry, together with the most important constituents which may be considered as typical of all plants in that industry, and hence may be used as evaluation of such wastes as objectionable discharges. This section is considered a very important one for outlining the activities of the other sections, as well as performing a highly informative and educational function for all groups or bodies dealing with the control of such wastes.

Section B on Methods of Analysis for Industrial Wastes, whose scope is the preparation of all analytical methods to be used in the detection, identification and evaluation of the components of water-borne industrial wastes. Since many standard methods are sometimes too long and involved for practical plant control work, this section plans, after it has

Petroleum Men Active On Subcommittee VII

A number of petroleum industry men are actively participating in the work of ASTM's Subcommittee VII on Water-Borne Industrial Wastes:

Roy F. Weston, Atlantic Refining Co., Philadelphia, chairman of Section B of the Subcommittee, on Methods of Analysis.

Orrin M. Elliott, Sun Oil Co., Philadelphia.

N. J. Gothard, Sinclair Refining Co., East Chicago.

Robert E. Price, Gulf Oil Corp., Port Arthur, Texas.

established standard or "referee" methods, to work out short-cut methods that can be used for most purposes.

Section C on Methods of Sampling, Gaging, and Preservation of Samples, whose scope is to prepare methods of sampling, gaging of flow, and preservation of samples during the period of transportation and analysis.

Section D on Methods of Reporting Results of Analysis, whose scope is to prepare methods of reporting analyses dependent upon the type of waste, etc.

Chairmen and secretaries have been appointed for each of these sections, and they are now organizing studies on specific projects.

Stresses Need for Such Work

The need for the work of the new group was pointedly brought out at the roundtable discussion in the introductory remarks by L. Kermit Herndon, professor of chemical engineering at Ohio State University. As he explained, there is not now available an authoritative reference work covering the measurement, sampling, analysis and characterization of water-borne industrial wastes.

Many groups, he continued, have been working on the problem of stream pollution and the effects of industrial wastes, but for the most part they have not been concerned with standard methods by which industry and the authorities can accurately determine what quantity of industrial waste a plant produces and what its characteristics are.

The round table discussion was held Thursday, June 30, as part of the 52nd annual meeting of the ASTM in Atlantic City. In addition to the brief introductory remarks by Mr. Herndon, two prepared papers were presented:

"Gaging and Sampling Water-Borne Industrial Wastes," by Charles F. Hauck, Hall Laboratories, Inc., Pittsburgh.

"The Need for Uniformity in Methods of Analysis and Reporting," by George D. Beal and S. A. Braley, Mellon Institute of Industrial Research, Pittsburgh.

Gaging and Sampling

In his paper on gaging and sampling, Mr. Hauck emphasized the need for a representative sample—one which is "similar in every essential characteristic to the stream from which it is taken" and in which "this likeness is preserved until examination of the sample is completed."

Too frequently, he continued, gross sampling errors vitiate the results of arduous analytical procedures carried out to obtain high accuracy in examining industrial waste waters. "Too often we concentrate our efforts on reducing errors in analysis from 0.2% to 0.15% while blithely ignoring errors of 20-20% in sample collection. This striving for accuracy to the right of the decimal point, while at the same time ignoring or assuming accuracy to the left of the decimal point, may be likened to the mediocre golfer who hopes to break a hundred through long hours of practice with the woods and irons to get a little more distance and better direction on the fairways, but forgets the unimpressive putter which is used more than any other club in the bag."

Eight Points to Consider

Eight points must be considered in obtaining a representative sample, according to Mr. Hauck:

1) Is the sample intended to reflect average or spot conditions?

2) Do the volume and composition of the waste water fluctuate widely or not?

3) Are such variations in composition periodic or random?

4) Where in the waste water flow route should the sample be obtained?

5) Is the waste water homogeneous at the sampling point?

6) How long should the sample lines be purged before the sample is taken?

7) Is it necessary to preserve the sample, and how can this be accomplished?

8) How much sample will be needed to make the analyses desired?

Spot vs. Composite Sampling

On the subject of spot vs. composite samples, Mr. Hauck said, in part: "The patterns of flow and concentration variations of the stream under surveillance and the precise purpose of sampling largely determine whether spot or composite samples should be collected. If the samples are intended to yield data on the total quantities of one or more waste water components, a composite sample will be satisfactory. On the other hand, if sampling is being done to establish the shape and amplitude of concentration fluctuations, a series of catch samples is necessary."

In cases where the characteristics of a waste water fluctuate widely and frequently, the volume is not excessively large, and a composite sample is satisfactory, it is occasionally simpler to impound the waste water and collect a homogeneous sample of the mixed flow.

One difficulty with composite samples, Mr. Hauck mentioned, is that they may blot out the real characteristics of a waste water which at various times carries substances which interact with each other, such as oxidizing and reducing agents, acids and bases, hot and cold water. As an example, he mentioned a textile finishing plant which discharges strongly alkaline waste waters for the first hour or two every day and acid waste during the remainder of the day. Although the pH of hourly composite samples made up of catch samples collected at 15-minute intervals ranged from 11.2 to 3.5, a 9-hour composite had a pH of 7.8. In this case, compositing concealed the high and low pH values of the mill's effluent which occurred at various times.

Regardless of the method of sampling, he suggested that in all instances the sample origin, method of collection, and the type and rate of operations during the sampling period should be part of its identification. "Unless all pertinent data are recorded," he said, "full interpretation of analytical results may not be possible."

Where to Collect Samples

Selection of a satisfactory sampling point is also of great importance in procuring a water specimen typical of the waste-water stream being surveyed, Mr. Hauck stated.

"What happens stepwise in plant processes and its bearing on the purpose of sampling are important. If various branch lines contribute substances which affect each other, such as acids and alkalis, a sample from the main stream will reflect only the net effect of these substances.

"Choice of sampling location is even more important when the profiles of composition changes are being sought. In such instances, especially when catch samples are collected, the timing of sampling at various points in the manufacturing process must be carefully synchronized. Finally, the point selected for sampling must be desirable from the standpoint of hydraulic stability. In general, points of great turbulence in the stream being sampled are desirable. Therefore, where gaging and sampling are done, usually it is better to sample just below a weir, orifice, nozzle, etc."

Size of Samples

Samples should be large enough, Mr. Hauck cautioned, to make all determinations which are desired. "In this respect," he continued, "it is better to err by collecting too much sample rather than too little. It is not unusual to want a little extra sample for tests not originally planned or for check analyses. Except for bacteriological examination, a quart is the minimum practical sample size, and, generally speaking, it is advisable to collect at least a two- or four-liter sample. When the sample must be preserved for one or more determinations, it is better to take duplicate or triplicate samples to insure the availability of complete data."

Later discussion, however, brought out the point that smaller samples

were entirely practical in many cases, particularly after it was determined what materials were present in the waste, and daily analyses were being made on a routine basis. One possible objection to larger-than-necessary samples mentioned during the discussion was the difficulty of transporting them from the sampling point to the laboratory.

Samples May Need "Protection"

"Equal in importance to collection of a good sample is the preservation of its representativeness between the time of sampling and analysis," Mr. Hauck declared in the closing portion of his paper.

"Waste water samples may be unstable due to their chemical, physical or biological characteristics. Concentrations of cyanide, phenol, hydrogen sulfide, dissolved oxygen, etc. change rather rapidly. Likewise, easily oxidized or reduced substances, temperature, and color are susceptible to rapid change. Solids frequently tend, depending on conditions, to coagulate or peptize, thus affecting the suspended solids value. Bacterial and micro-organism counts in water samples are notably "unfixed." Waterborne wastes carrying nutrient organics such as dissolved carbohydrates and proteins will be affected quickly by biological activity."

Mr. Hauck recommended that time delays between sample collection and analysis be reduced to a minimum, and when this was not possible that refrigeration of the sample and the use of chemical preservatives be employed.

The Need for Uniformity

In his paper on the need for uniformity in methods of analysis and reporting, Mr. Braley, a senior fellow at Mellon Institute, pointed out that most of the analytical procedures applied to industrial water today must be regarded as end-use methods. They determine the suitability of the water for some particular use or group of uses.

"The testing of water to determine its suitability for end uses," he continued, "has led to the development of empirical methods of analysis, which are coupled in turn with calculations using factors that specify the required degree of treatment rather than chemical composition.

"Such analytical procedures are operators' methods, for use solely in guiding plant operations. Although they are based upon and employ chemical reactions, they do not represent chemical control, but only operational control. They may be compared quite properly with alarm signals, indicating only that something is wrong without a proper diagnosis of the trouble. Excellent in their way and based upon definite reactions, they are devised for technicians rather than chemists, for watchmen rather than diagnosticians."

Types of Procedures Desired

In Mr. Braley's opinion, the types of analytical procedures that should be available for water-borne wastes are those which will give precise information as to the proximate or ultimate constitution of the solution or suspension that is the waste; i.e., either concentrations of elements or ions, or specific information as to the nature of the larger, more complex molecules present.

"It should be possible," he said, "to fit the analytical data so obtained into systems of tabulation with a minimum of correction. As a simple illustration, when determining acidity or alkalinity of waters it would be desirable if the results could be related one to the other, as by the use of a single indicator."

Most of the problems in waste disposal, Mr. Braley stated, have to do with wastes of organic composition, and the principal criteria of these wastes are their oxygen saturation and their oxygen demand.

"Although there seems to be pretty general acceptance of present standard methods for these determinations by sanitary chemists, it is certain that there are no procedures applied to water that lead to more misunderstandings regarding the quality of waters and wastes. It is our opinion that no determination requires a new agreement regarding standard procedures more than does the determination of oxygen demand and what actually constitutes oxygen demand."

Requisites for Standard Methods

Answering the question "What shall we look for in our standard methods in order that we may have proper co-operation between plant chemists, and our operating and sanitary engineers?" Mr. Braley proposed a number of requisites:

1) There should be an agreement as to the purpose of any proposed method.

2) There should be agreement also as to the theory of a determination. Quantitative and qualitative tests must have significance; they must be very definitely indicative of some particular condition.

3) Every procedure used must be capable of duplication as to result, and, more important yet, must be capable of verification as to significance by the use of a reference standard under the full conditions of the test.

4) When agreement is reached as to any procedure to use, that agreement must be as to every detail. These details must be so described that nothing will be left to the imagination of the analyst, no matter how highly skilled in the art he may be.

5) Collection, packaging, transportation and storage of samples must be so clearly prescribed as to insure to any analyst that he is dealing with an authentic sample that represents actual conditions at the time and place of sampling.

6) Scrupulous attention must be given to devising systems of calculation and reporting of data, in order that those data may be intelligible to any other person so skilled in the art.

"Finally," he concluded, "it might as well be frankly admitted that the analysis of water-borne industrial wastes must, to a large extent, be started over again from scratch. We may hope that the experience already gained may serve to co-ordinate procedures to be used, but the lack of correlation, and even of simple care, in what has been done before means that, in many cases, there has been a shameful waste of effort that now must be overcome."

Summer Reading Material

So important to industry and the public alike has the subject of disposal of plant wastes become that articles on the topic are now appearing in the general magazines.

The July 9th issue of *Saturday Evening Post* carried an article "They're Cleaning Up Pennsylvania's Foulest River," describing the waste disposal program for the Schuylkill River. Atlantic Refining Co., whose Point Breeze refinery is located on the Schuylkill, has been a leader among industrial plants in disposal of wastes.

Business Week, issue of July 9th, carries an editorial, "Industry's Responsibility for Unclean Waters."

PETROLEUM PROCESSING was among the first of the journals of industry to call attention to the growing problem of disposal of plant wastes. It published in 1946-47 a series of articles "Modern Methods of Disposal of Refinery Wastes" by W. B. Hart, Atlantic Refining Co., Philadelphia, a leading authority on the subject. So well received was this series that it was republished in book form and is now being used as a reference book by industrial and sewage waste engineers generally.

Raw Crude Oil Is Charged Directly To 2600 b/d Catalytic Cracking Unit

By H. A. BROWN, Superintendent, Frontier Refining Co.
and M. J. STERBA, Universal Oil Products Co.

DURING the past year Frontier Refining Co. at Cheyenne, Wyo., has been processing a sour but salt-free crude oil in its Fluid catalytic cracking unit without apparent harm to the synthetic catalyst in the unit. The raw crude is handled in admixture with Wyoming gas oils. Distillation of the crude, desulfurization of its gasoline, and cracking of the topped crude are all being accomplished in a single processing step.

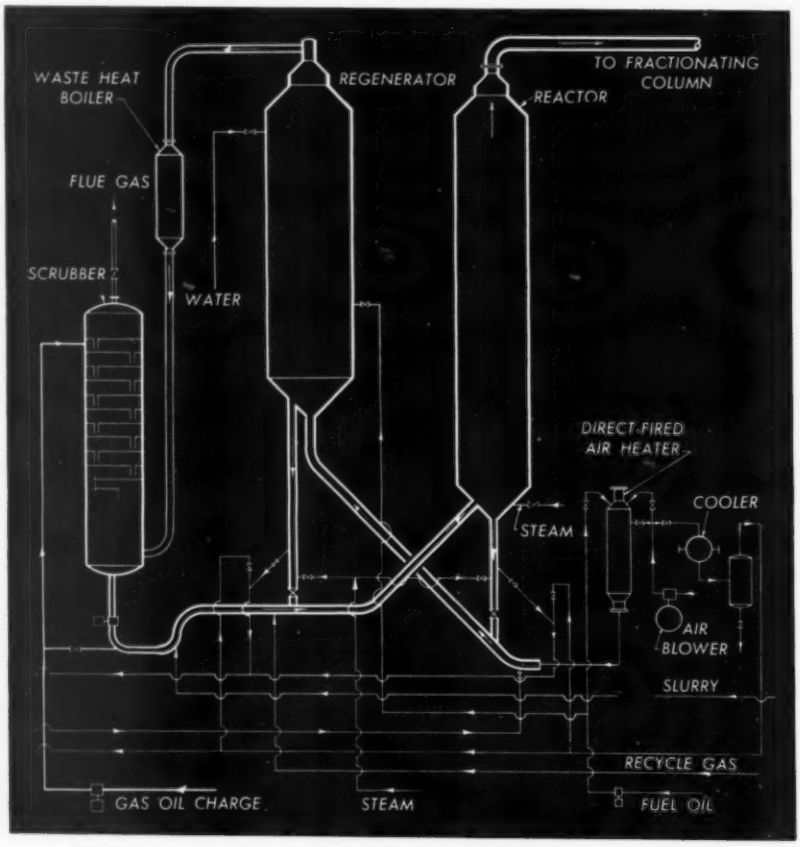
The catalytic cracking unit was first put on stream at Frontier's refinery early in 1944, with a design capacity of 2600 b/d. During the war the unit was operated to produce aviation gasoline base stock, and alkylation feed comprising isobutane and olefins. Since the end of the war it has been in continuous operation, producing motor gasoline, with C_3 and C_4 olefin recovery to provide feed stock for polymerization.

With increasing quantities of crude deliveries to the refinery, and with limited crude distillation facilities at hand, it became of interest to consider the processing of a particular

FRONTIER "CAT" CRACKER PIONEERED DESIGN FEATURES

Frontier's Fluid catalytic cracking unit, as described by Newman[3] and Read[4], had several features of design which made it a pioneer among catalytic cracking units of 1944, some of which features have been adopted since then in certain modern units.

For instance, this was the first unit which had its reactor and regenerator placed at the same elevation, thus reducing the over-all height from 180 ft to about 100 ft. This side-by-side design philosophy has been followed in several units of recent construction.[1, 2, 5, 6] It was the first unit to employ a pressured regenerator, from which the flow of exit flue gas was automatically controlled by a valve actuated to hold a constant differential pressure between the tops of the reactor and regenerator. The use of pressured regenerators so controlled is now rather common practice in modern units.



Flow diagram of the Frontier Fluid unit, which when built in 1944 incorporated several design innovations which have since become standard for this type of catalytic cracking equipment

Prior to 1944, it was general practice to construct the regenerator riser and standpipe with internal refractory insulation. A new departure incorporated in the Frontier design was the use of 4-6 chrome alloy for the catalyst-carrying lines, insulated on the outside but in direct contact with the catalyst on the inside. This construction feature, which eliminated internal refractory maintenance, was proved to be feasible, and is now commonly used in modern designs.

Another innovation employed in the Frontier unit was the use of an oil scrubber in place of the conventional and more expensive Cottrell precipitator to recover catalyst from the flue gas stream leaving the regenerator. While the use of the oil scrubber has proved to be satisfactory in its operation, up-to-date units are so designed that they require no equipment whatever to recover catalyst from the flue gas stream leaving the regenerator.

crude directly and in its entirety in the catalytic cracking unit.

Properties of this crude oil from the Neiber field in Wyoming are detailed in Table 1, which shows its rather high sulfur content, high gasoline, and negligible salt contents. The crude contains only 2.4% of −0.1° API bottoms after removal of gas oil by vacuum distillation. The gasoline from Neiber crude contains 0.44% sulfur, almost half of which appears as mercaptans.

It was thought that if this crude could be processed as such by the catalytic cracking unit without harm to the catalyst, it would accomplish distillation, partial desulfurization of the gasoline, and cracking of the topped crude in a single processing step, thereby relieving overburdened crude distillation and gasoline desulfurization facilities. With this objective in mind, the processing in the catalytic cracking unit of Neiber crude along with gas oil from other crudes was begun in February, 1948, and because of the advantage of this method of operation in the overall refinery scheme, it has continued to date without apparent harm to the cracking properties of the catalyst.

Operating Conditions

The general arrangement of equipment and process flow through the catalyst section of the Frontier unit has been described by Newman. (3) In current operations the crude oil is fed at atmospheric temperature and without preheat directly to the reactor riser, while virgin gas oils from other sources, heavy recycle, and main fractionator bottoms are fed to the top of the flue gas scrubber to recover catalyst from the regenerator exit gases which enter the bottom of the scrubber and pass upward countercurrent to the flow of oil.

Oil leaving the bottom of the scrubber is charged with recovered catalyst to the reactor riser. Gasoline, light cycle oil, and heavy cycle oil are produced as net liquid streams by the unit, while the fractionator bottoms stream is recycled to extinction.

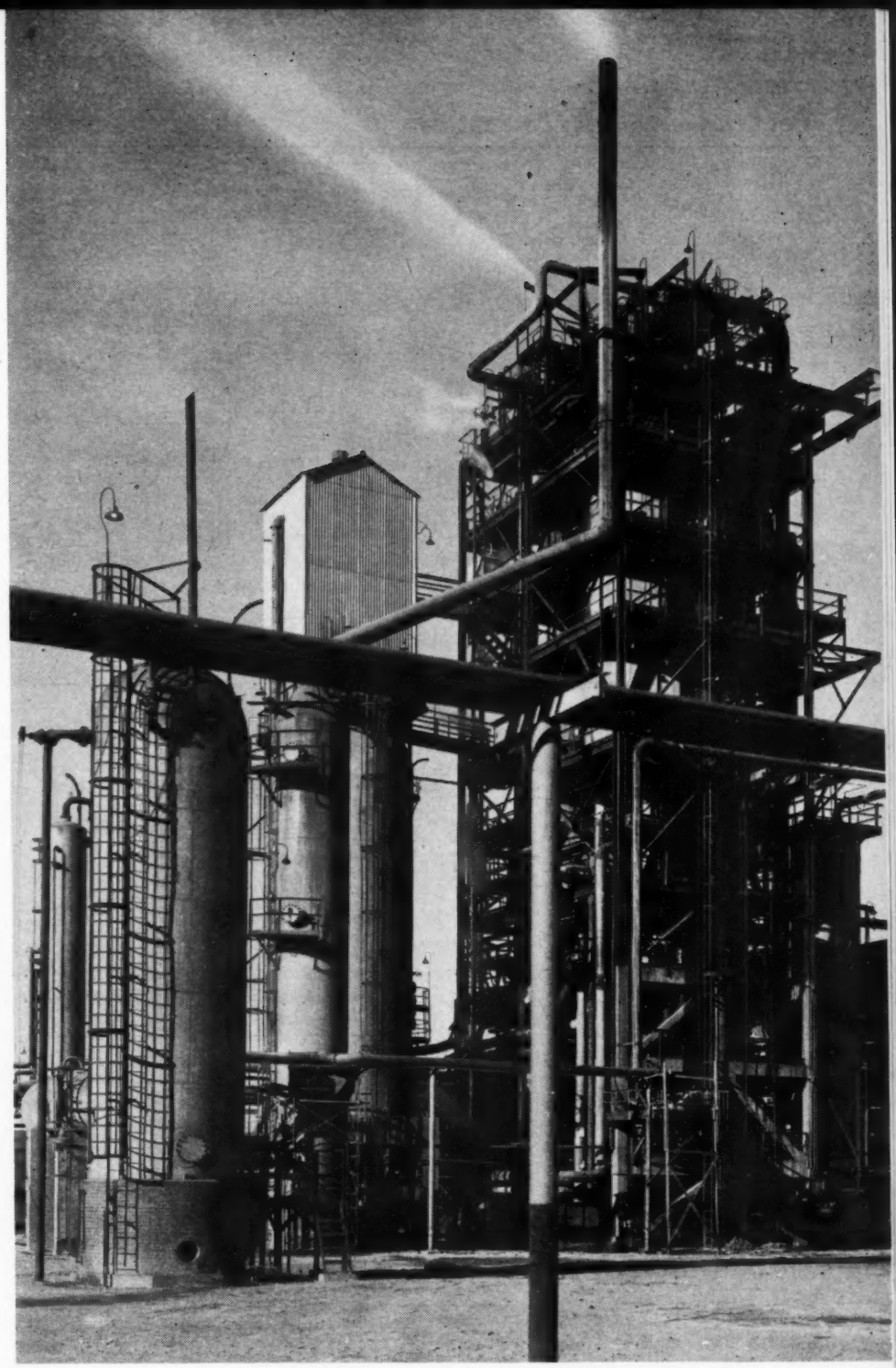
A twenty-four hour test period obtained in August, 1948, is typical of crude processing operations during the run which began on Dec. 17, 1947. Operating conditions for this test period are shown in Table 2.

Yields, Product Distribution

Product distribution detailed in Table 3 shows a yield of 54% of debutanized gasoline, 13.2% of C_4 and 8.6% of C_3. The gas recovery unit to which gasoline and light hydrocarbons are fed from the catalytic cracker actually prepares a C_3-C_4 stream as charge material to a polymerization unit, and a stabilized gasoline stream. Inspections of the stabilized gasoline shown in Table 4 are for the combined 1337 b/d of debutanized gasoline and 187 b/d of 28-lb. RVP polymer made during the test period.

Flue gas leaving the oil scrubber is finally contacted with water before it is discharged to the atmosphere. At this point a small amount (about 35 b/d) of oil is recovered in a skimming pit and is processed in thermal cracking units in the refinery. While this stream is shown as a product in Table 3, it actually did not pass through the reactor, but was picked up by the flue gas as it passed through the oil scrubber at an exit temperature of about 200° F.

Comparison of the 0.202% mercaptan sulfur content of the straight run gasoline in Table 1 with the 0.008% mercaptan sulfur content of the gasoline leaving the catalytic cracker (Table 4) would indicate desulfurization of the straight run gasoline at least to the extent of its mercaptan content in passing



General view of the 2600 b/d Fluid catalytic cracking unit at Frontier's Cheyenne, Wyo., refinery. As now operated, the unit charges raw crude in admixture with gas oil, and performs three operations—crude distillation, catalytic cracking, and gasoline desulfurization

TABLE 1—Properties of Neiber Crude

	Crude Oil	425° F. E-P Gasoline	Topped Crude After Gasoline
Volume Percent of Crude	100.0	52.5	47.5
Gravity, ° API @ 60° F.	37.6	56.0	21.4
Total Sulfur, Wt. %	1.82	0.44	2.93
Mercaptan Sulfur, Wt. %	....	0.202	....
Hydrogen Sulfide, Wt. %	0.035	0.063	....
Reid Vapor Pressure	3.4	5.0	....
Octane Numbers:			
Motor Method, Clear	....	50.7	....
Motor Method, +3 cc TEL/Gal	....	62.2	....
Cold Test, ° F.	<—30	....	—20
Viscosity, SUS @ 100° F.	33.3	....	111
Salt as NaCl, Lbs/1000 Bbls.	Nil	....	....
Distillation, 100 Ml., ° F.:			
IBP	134	112	460*
10%	215	160	528*
30%	303	218	603*
50%	423	267	695*
70%	594	314	810*
90%	742	375	972*
E.P.	...	424	...
Light Hydrocarbon Content, Vol. %:			
C_3H_8	0.2	...	...
iC_4H_{10}	0.3	...	...
nC_4H_{10}	1.4	...	...
C_5H_{12}	3.6	...	...

* Vacuum distillation; temperatures corrected to 760 mm. Hg.

TABLE 2 — Operating Conditions for Test Period

Temperatures, ° F.:	
Reactor dense phase	887
Scrubber bottoms to reactor	299
Crude oil to reactor	66
Regenerator dense phase	1,106
Flue gas to scrubber	367
Flue gas leaving scrubber	205
Pressures, psig.:	
Reactor top	16.1
Regenerator top	15.7
Barometric pressure, mm. Hg.	616
Rates:	
Neiber crude to reactor, b/d	797
Virgin gas oil to reactor, b/d	1,675
Heavy recycle to scrubber, b/d	1,010
Fractionator bottoms to scrubber, b/d	266
Stripping steam, lb./hr.	1,710
Injection gas,* SCFH	18,900
Catalyst circulation rate, lb./hr.	433,000

* Recycled to reactor from first stage receiver gas compressor.

through the catalytic unit. The sulfur content of the straight run gasoline on a mercaptan- and hydrogen sulfide-free basis is 0.175%, which is very nearly the same as the 0.17% total sulfur concentration in the stabilized gasoline stream leaving the cracking unit. If it is assumed that no desulfurization of the straight run gasoline was accomplished beyond removal of H_2S and mercaptan decomposition, then the sulfur content of the true cracked gasoline must be about 0.17%, which is rather low considering that it was produced from a gas oil of 1.73% sulfur and a topped crude containing 2.93% sulfur.

All distillations of feeds and products were made at sea level, and it should be noted that gasoline end points of about 425° F. reported in these tables would correspond to end point temperatures of about 405° F. if they were measured in Cheyenne.

Cracking Catalyst Used

Processing of the nature described has been accomplished with a ground silica-alumina catalyst, which at the time of the test had the following properties:

Surface area, sq. meters/gram	142
UOP weight activity	30
Iron, wt. %	0.47
Carbon on regenerated catalyst, wt. %	0.11
Screen analysis, wt. %:	
on 70 mesh	0.6
70-100 mesh	2.1
100-200 mesh	21.6
200-270 mesh	20.4
thru 270 mesh	55.3

During the calendar year 1948, 138 tons of fresh catalyst were added to the unit to replace normal losses from the flue gas scrubber. This corresponds to a catalyst consumption of approximately 0.30 lbs. per bbl. of fresh feed to the reactor, and at this replacement rate the activity was constant during the year at the equilibrium value shown above.

It should be emphasized that processing of the nature described should be considered only if the crude is free of salt, contains very small amounts of residual bottoms, and if the metallic content of the crude is extremely low.

Summary

The Frontier catalytic cracking unit has processed Neiber crude in admixture with Wyoming gas oils for over a year without apparent harm to the catalyst. Distillation of the crude, desulfurization of its gasoline, and cracking of the topped crude have been accomplished in one processing step.

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TABLE 3—Yields and Product Distribution from Catalytic Cracking

Charge to Unit	B/D	Vol. %	° API	Lb./Hr.	Wt. %
Neiber Crude	797	32.3	37.6	9,710	31.2
Virgin Gas Oil	1,675	67.7	28.7	21,550	68.8
	2,472	100.0		31,260	100.0
Products					
H_2S in Process Gas	....	....	....	196	0.6
C_2 and Lighter (23,000 SCFH)	....	....	....	843	2.7
Propylene	138	5.6	....	1,061	3.4
Propane	74	3.0	....	552	1.8
Butylenes	141	5.7	....	1,240	4.0
Butanes	184	7.5	....	1,523	4.9
Debutanized Gasoline	1,337	54.1	54.1	14,530	46.5
Light Cycle Oil	302	12.2	26.3	3,950	12.6
Heavy Cycle Oil	318	12.9	24.4	4,210	13.5
Oil from Scrubber Pit	36	1.5	30.0	460	1.5
Catalyst Deposit	....	....	....	2,124	6.8
Product Recovery				30,689	98.3

TABLE 4—Feed and Product Inspections

	Crude Charge	Gas Oil Charge	Stabilized Gasoline	Light Cycle Oil	Heavy Cycle Oil
Gravity, ° API @ 60° F.	37.6	28.7	55.8	26.3	24.4
Total Sulfur, Wt. %	1.82	1.73	0.17	1.68	1.79
Mercaptan Sulfur, Wt. %	....	....	0.008	....	....
Aniline Point, ° F.	....	163	....	107.6	137.1
Viscosity, SSU @ 100° F.	33.3	55.6	....	35.2	42.0
Cold Test, ° F.	....	15	....	—5	30
Reid Vapor Pressure	3.4	....	6.9	....	....
Octane Numbers					
Research Clear	....	....	87.6	....	....
Research +3 cc TEL/Gallon	....	....	94.6	....	....
Motor Clear	....	....	77.0	....	....
Motor +3 cc TEL/Gallon	....	....	83.3	....	....
Salt as NaCl, Lbs/1000 Bbls.	Nil				
Distillation, 100 Ml., ° F.:					
IBP	134	497*	100	438	450
10%	215	580*	140	473	531
30%	303	634*	183	495	562
50%	423	656*	241	512	587
70%	594	700*	305	534	614
90%	742	771*	377	580	652
E.P.	...	...	427	642	706
Vol. % C_4	...	...	4.1	...	...

* Vacuum distillation; temperatures corrected to 760 mm. Hg.

REFINING BY ADSORPTION

New Cyclic Adsorption Process Separates High Purity Aromatics and Olefins from Petroleum

By S. EAGLE and J. W. SCOTT

California Research Corp. Richmond, Cal.

High yield and purity of product is achieved in a cyclic adsorption process for the liquid-phase separation of aromatics or olefins from saturated aliphatic hydrocarbons. Early development work was with a moving adsorbent bed similar to the catalyst bed in a TCC unit. Limitations here led to the use of fixed beds of adsorbent of fine particle size, and changing feed injection points and product withdrawal points. Cyclic operation is secured through automatically shifting the adsorption columns counter direction to liquid flow. Application in the petroleum refining industry includes the manufacture of petroleum specialty products and chemical intermediates.

REFINING BY ADSORPTION is believed to have many valuable applications in petroleum refining and chemical processing. Its greatest value in the petroleum industry is its unusual ability to make almost quantitative separation of aromatics and olefins from the other components of many different feed stocks of wide boiling range.(1)

In many respects, the results and objectives of adsorption refining resemble those of solvent treating, except that the separations obtained are more complete. Hence, emphasis in the process research and development was placed upon commercial applications in which the removal of aromatics and strongly adsorbed compounds from the feed stock would increase markedly the quality of the remaining product, or in which separation and recovery of the aromatics or olefins for themselves would be desirable.

The early studies indicated that adsorption refining stood a good chance of being competitive with, or superior to conventional treating processes such as SO_2, phenol, Duosol, furfural, and acid treating. The results from experiments in laboratory silica gel columns showed that higher yields of raffinates of better quality were attainable by adsorption than are attainable by conventional solvent refining processes. This result was especially outstanding in the case of production of premium kerosene, Diesel fuels, spray oils, and lubricating oils. Likewise, aromatics and olefins of high purity were separated from a variety of petroleum naphtha fractions.

The similarity between adsorption and extraction in making such separations makes it convenient to refer to the least strongly adsorbed fraction as raffinate (or percolate), and the strongly held material as extract (or adsorbate).

The early work in developing the commercial adsorption process described in this paper included design, construction, and operation of continuous and multiple fixed-bed pilot units to study process variables and to obtain data for design and economic evaluation of a commercial plant. The continuous pilot units used a moving adsorbent bed somewhat similar to the catalyst bed in a Thermofor catalytic cracking unit. However, basic research and pilot plant results showed that limitations exist in application of a moving adsorbent bed to the liquid phase separations that are of greatest interest in petroleum refining.

These include: (1) limitation in liquid throughput to avoid lifting of the adsorbent beads; this limitation is primarily a function of bead diameter and liquid viscosity; (2) limitation in liquid diffusion rate in the individual adsorbent particles resulting from the fact that large particles must be used to avoid pressure drop and lifting of the bed; (3) attrition or breakage of the particles, which is severe because highly selective adsorbents such as silica gel are quite susceptible to fracture by adsorptive and mechanical forces when in the form of the large adsorbent particles or beads that must be used in moving bed processes.

The fixed-bed pilot unit studies resulted in the development by California Research Corp. of a new cyclic fixed-bed adsorption process that avoids these problems and utilizes the high diffusivity characteristics of small adsorbent particles. The new cyclic adsorption process described in this paper differs from the moving bed process in the use of fixed beds of adsorbent of fine particle size and changing feed injection points and product withdrawal points, instead of the moving bed of coarse adsorbent and single feed injection point and product withdrawal point characteristic of the moving-bed process.

A typical cyclic adsorption plant suitable for achieving highly efficient separation of aromatics or olefins from saturated aliphatic hydrocarbons is shown in the schematic flow diagram Fig. 1. The adsorption columns (A to I) may be packed with silica gel, carbon, or other suitable adsorbent. The columns are shifted in counter-direction to the liquid flow on a regular cycle time through: (1) raffinate refining, (2) extract enriching, (3) hot stripping and, (4) cooling. The number of columns in each zone is determined by the desired purity of raffinate and extract, and by the residence times required in regeneration and cooling.

Feed is introduced into the first column in the raffinate refining zone combined with effluent from the last column of the extract enriching zone.

A recycle of the first liquid effluent from the stripping zone, comprising strippant and the first eluted adsorbate, is introduced into the first column of the extract enriching zone.

Hot strippant enters the first column of the stripping zone in sufficient quantity to remove extract from the adsorbent and thus to regenerate the adsorbent for re-use. After recycle of the first effluent, the remaining strippant - extract mixture goes through a surge vessel to the extract stabilizer.

Cold strippant is introduced into the cooling zone in sufficient quantity to return the adsorbent to a favorable temperature for raffinate refining. The first effluent from the cooling zone is hot strippant, which may be diverted to hot strippant storage.

The first effluent from the raffinate refining zone consists of cold strippant, which may be diverted to cold strippant storage. The balance

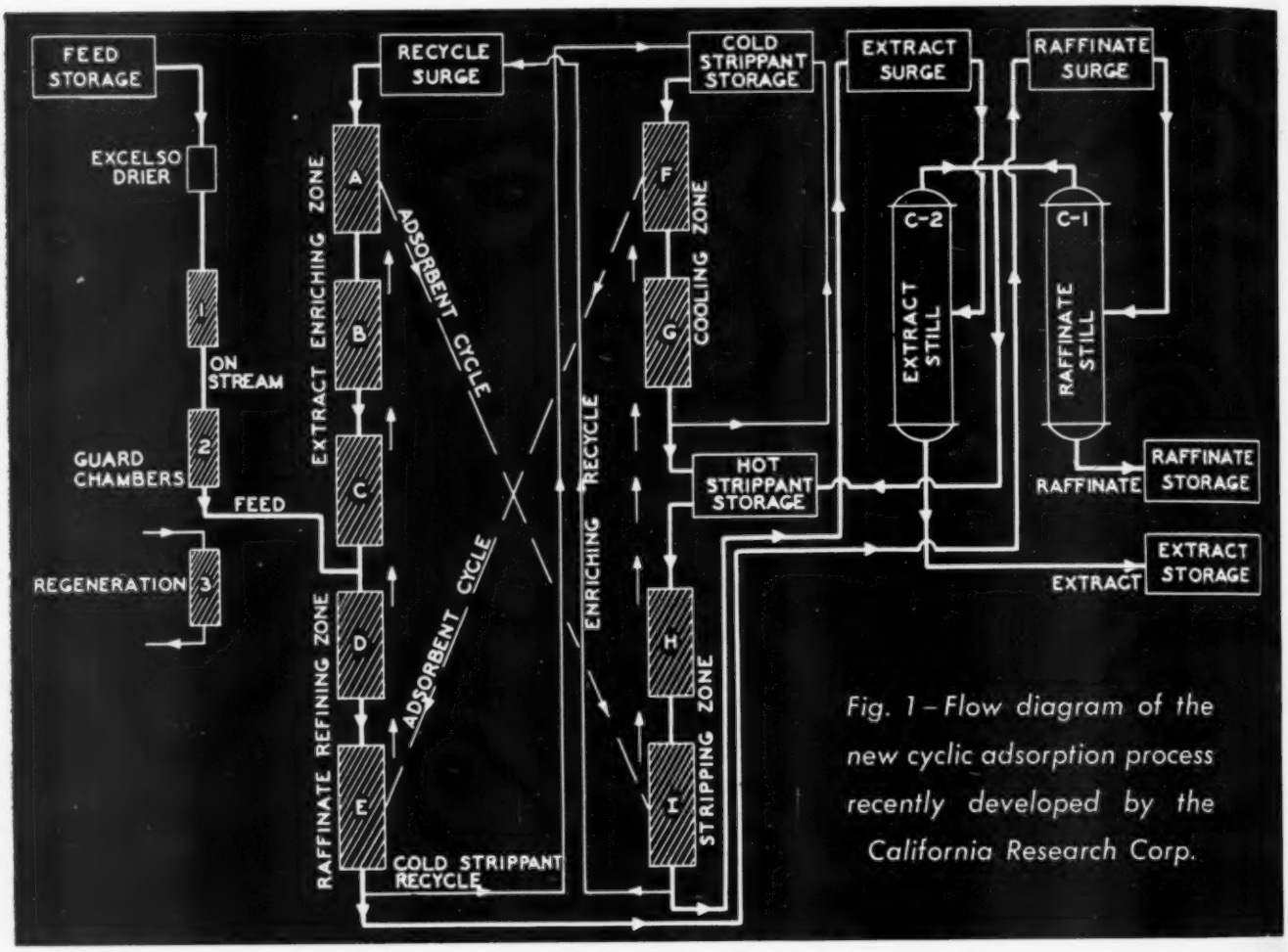

Fig. 1 – Flow diagram of the new cyclic adsorption process recently developed by the California Research Corp.

of the effluent strippant-raffinate mixture goes through a surge vessel to the raffinate stabilizer.

Excelso driers and guard chambers are provided to remove water and other strongly-adsorbed compounds from the feed. They may not be necessary in all cases, but often are desirable to prolong the life of the main body of adsorbent. Clean stocks such as hydroformed gasoline may contain about 0.02% of polar material, mostly dissolved water. Kerosene distillate, cracked naphtha and light gas oils may contain about 0.1 to 0.5% of polar or other strongly adsorbed compounds that cannot be removed readily by moderate quantities of paraffinic stripping liquids, even at temperatures of 200-300° F. The guard chambers contain adsorbent designed to remove these objectionable trace compounds from the feed stream. Periodically the guard chambers are subjected to a special regeneration cycle during which the accumulated adsorbed materials are desorbed and the adsorbent is reactivated for re-use. Ordinarily, the guard chambers require regeneration far less frequently than do the main adsorption columns.

Proper choice of adsorbent for use in both the guard chambers and main adsorption columns is important because the cost of adsorption refining is markedly dependent upon the selectivity, diffusivity, size, and life of the adsorbent. The first three properties are important in determining the size and investment required for a projected plant, and the rate of decline in activity of the adsorbent is an important factor in its operating cost. The total inventory of adsorbent required in the main adsorption section primarily depends upon: (1) per cent of adsorbate to be removed from the feed, (2) selective capacity of the adsorbent for the separation involved, (3) required purity of raffinate and extract products, (4) permissible liquid velocities without excessive pressure drop, (5) rate of mass transfer in the adsorbent particles, (6) the rate of heat transfer in heating and cooling adsorbent, (7) the number and size of the adsorption columns and the operating cycle time.

The optimum number and size of adsorption columns are determined by the character of the feed, the desired product quality, and economic considerations in construction. Design pressures will limit the number and size of columns if the adsorbent partcles are very small, especially if the feed stock is of high viscosity. Booster pumps may be provided between columns to minimize the pressure limitation. The volume of adsorbent required in each column is fixed by the cycle time, the quantity of adsorbate to be removed, and the selectivity of the adsorbent. Column diameters are fixed for a given adsorbent and feed by the limiting liquid flow velocities at which the desired separation can be made without excessive pressure drop through the adsorbent.

Good stripping liquids (strippants) are those having the following properties: (1) less strongly adsorbed than the adsorbate, (2) good solubility for the adsorbate, (3) low viscosity, (4) readily separable by distillation from the feed components, and (5) relatively low vapor pressure under operating conditions. Light petroleum solvents such as pentane, hexane, heptane, or petroleum ethers are favorable strippants in many applications of adsorption in petroleum refining. These solvents usually are cheap, readily available, and have suitable properties for this service. They have been widely used in chromatographic analysis[2] to wash various feed components from adsorption columns into successive percolate fractions.

Pentane, iso-octane and a de-aromatized kerosene fraction were in-

vestigated in detail in the course of the development work. All were found satisfactory as strippants for regenerating the main adsorption columns in different special applications of the process in petroleum refining. Pentane borders the low boiling limit from the standpoint of vapor pressure, and kerosene boiling range strippant is near the high viscosity limit from the standpoint of diffusion and pressure drop.

The optimum operating temperatures for adsorption and stripping depend upon the viscosity of the feed and of the stripping liquids, the temperature coefficients of adsorption equilibria, and the desired purity of products. In most cases, raffinate refining and extract enriching are performed at atmospheric temperature, and extract is washed from the adsorbent with strippant at a higher temperature, as dictated by the economic balance between quantity of strippant, pressure drop, required heat input, and product quality. The yield and quality of products for a given plant and fixed feed rate are controlled by the cycle time, and by the quantities of recycle and of strippant. Appropriate segregation of hot and cold stripping liquids is made to obtain optimum heat economy without contamination of the raffinate and extract products.

Pilot Plant Studies

Adsorption studies were made in a 0.5-1.0 b/d, 8-column pilot unit capable of operating at temperatures of 60-350° F. Charge stocks ranging from light hydroformed and cracked naphthas to lubricating oil distillates were evaluated for upgrading of raffinate and production of high purity aromatics or olefins. The preferred operating conditions were found to depend upon the character of the charge stock and adsorbent, but usually were within the following range:

Feed to Adsorbent Ratio, gals/lb.	0.05-0.10
Recycle to Adsorbent Ratios, gals/lb.	0.08-0.14
Strippant to Adsorbent Ratios, gals/lb.	0.2 -0.5
Cycle Time, Hours	0.25-2.0
Liquid Velocities, gals/hr. per sq. ft.	100-1000

Typical product yields and inspection for refining of petroleum distillates in a cyclic adsorption unit are shown in Table 1. Feed to adsorbent ratios decrease with the fraction of aromatics or olefins in the charge stock. The adsorbent requirement is the minimum in separating aromatics from paraffins-naphthenes and is greater in the separation of aromatics from olefins, or of olefins from a paraffins-naphthenes. Increasing the enriching recycle increases extract purity, but may contaminate the raffinate with adsorbate if the feed to adsorbent ratio is near the optimum economic value. Decreasing the strippant to adsorbent ratio results in less complete regeneration and also results in production of raffinate of lower purity.

The adsorption raffinate from kerosene distillate is a high quality lamp oil. Raffinates from gas oils make high cetane Diesel fuels. Adsorption refined raffinates usually are very low in sulfur content.

High Purity Aromatics

Cyclic adsorption plants can be operated to give practically quantitative separation of high purity aromatics from wide boiling range petroleum fractions. An example of recovery of high purity aromatics by adsorption from hydroformed naphtha is shown in Table 2. Because the chief impurities in the aromatic fraction are olefins, aromatics of very

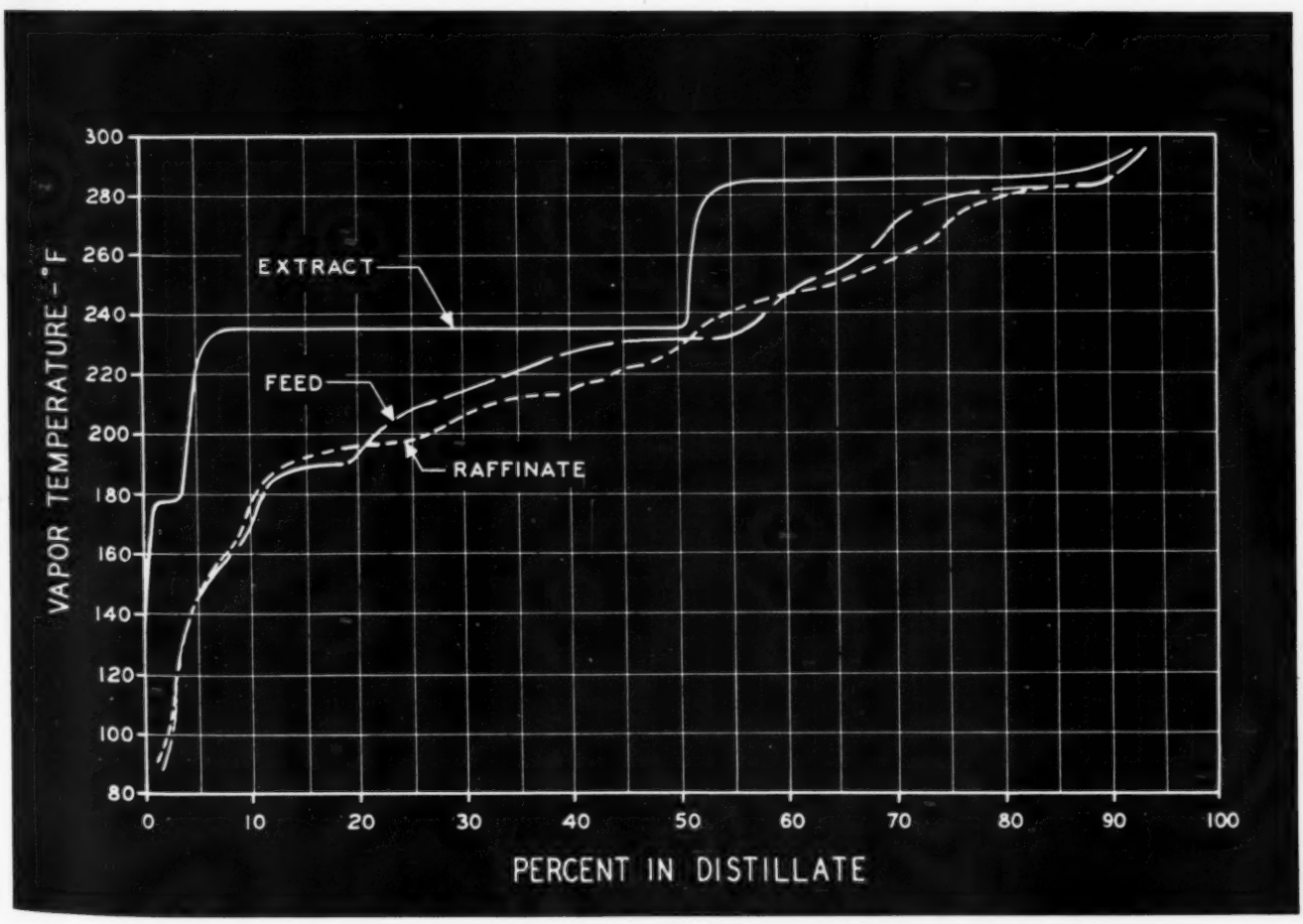

Fig. 2—Analytical distillation, hydroformed gasoline and cyclic adsorption products

TABLE 1—Cyclic Adsorption Refining of Petroleum Distillates

Charge Stock	Hydroformed Naphtha	Kerosine Distillate	Houdry Gas Oil	TCC Gas Oil	Cracked Naphtha	De-aromatized Cracked Naphtha	Pentane Diluted De-aromatized Cracked Naphtha
Gravity, °API	50.9	39.9	27.2	28.2	50.0	56.1	76.8
Aniline Point, °F	69	132	107	126	95	133	...
Bromine No. (g/100 g)	3	0	9	11	71	55	39
Aromatics, Vol. %	35.8	22.5	40	41	19	...	...
Distillation, °F							
I.B.P.	134	376	417	431	214	216	90
10% Vol.	206	396	465	472	230	240	...
50% Vol.	242	424	500	563	272	274	...
90% Vol.	269	474	590	620	354	350	...
Strippant	(1) Dearomatized Kerosine (2) Pentane	Isooctane	Isooctane	Isooctane	Pentane	Pentane	Pentane
Recycle to Feed Ratio (gal./gal.)	2.27	1:02	1.74	1.74	1.28	2.4	1.8
Strippant to Feed Ratio (gal./gal.)	4.7	2.6	5.5	5.5	4.9	5.2	3.8
Cycle Time, Hours	1	3	0.75	0.75	0.75	0.75	0.75
Raffinate							
Yield, Vol. % Charge	65	76	59	58	78	53	72
Gravity, °API	60.7	44.3	36.0	40.1	56.6	57.7	90.0
Aniline Point, °F	137	165	174	189	132	150	...
Bromine No. (g/100 g)	4	0	0	0	55	1	5
Aromatics, Vol. %	1—	1—	1	1	1—	...	...
Extract							
Yield, Vol. % Charge	35	24	41	42	22	47	28
Gravity, °API	31.3	22.4	13.6	12.8	32.0	55.0	53.2
Aniline Point, °F (Blend)	—88	—40	—49	—53	—20	107	93
Bromine No. (g/100 g)	1	0	20	26	80	117	137
Aromatics, Vol. %	99.8	92	95	95	87	...	...

TABLE 2—Cyclic Adsorption Refining of Hydroformed Naphtha

Stock	Hydroformed Naphtha Charge	Raffinate Product	Extract Product
Aromatics, Vol. %	35.8	1—	99+
Gravity, °API	50.9	60.7	31.2
Aniline Point, °F	69	137	—88 (Blend)

Analytical Distillation	Yield Vol. %	Aromatics Vol. % Cut	Aromatics Vol. %	Yield Vol. %	Aromatics Vol. % Cut	Olefin Vol. % Cut	Identity Aromatic
86-196, °F	19.7	8.2		4.3	90	7	Benzene
196-250, °F	42.7	36.9		47.1	99+	1—	Toluene
250-293, °F	32.4	51.0		41.4	99+	1—	Xylenes
293+, °F	5.2	17.0		7.2	99+	1—	C_9
Whole Stock	100.0	35.8	1—	100.0	99+	1—	

TABLE 3—Cyclic Adsorption Refining of Thermally Cracked Naphtha

Stock	Feed Cracked Naphtha	First Pass Extract	First Pass** Raffinate	Second Pass Extract	Second Pass Raffinate
Gravity, °API	50.0	32.6	56.6	53.2	57.7
Aniline Point, °F	95	—30 (Bl.)	132	93	150
Bromine No., g/100 g	71	80	55	137	1
Compound Types*	PNOA	A	PNO	O	PN

* P=Paraffin, N=Naphthene, O=Aliphatic Olefin, A=Aromatic Structures.
** First Pass Raffinate is Feed for Second Pass Operation.

high purity can be prepared by acid treating the extract to remove olefins, neutralizing, washing, and distilling. Trace paraffinic impurities may be as large as 3% in the benzene fraction, but are less than 0.2% in the toluene, mixed xylenes, and higher-aromatic fractions. In pilot runs, toluene fractions, a mixed-xylene fraction, and a C_9 aromatic fraction, each of over 99.8% purity, have been obtained as adsorption extracts without acid treating. Analytical distillations of the hydroformed charge stock, raffinate and extract from a run in a cyclic adsorption plant are shown in Figure 2.

High Purity Olefins

High purity olefins likewise may be obtained from thermally cracked naphtha by appropriate processing in a cyclic adsorption unit, as is shown in Table 3. Wide boiling range cracked naphtha was separated readily into saturate, aliphatic olefin, and aromatic type fractions. Olefin concentrates are separated easily by simple fractional distillation to give a series of high purity olefin cuts useful as chemical intermediates.

Economics of Adsorption Refining

Extensive economic studies were made on liquid phase adsorption refining based on the cyclic adsorption process for plants processing from 2,000 to 15,000 b/c/d of feed. The operating cost was found to be in the range of 1 to 3 cents per gallon of feed, and the total production cost, including five-year plant payout and two-year adsorbent life, in the range 1.5 to 4 cents per gallon of feed. The production cost chargeable to adsorption for recovery of pure aromatics is about 6 cents per gallon of aromatic.

The cyclic adsorption process is believed to have many valuable industrial applications outside of the petroleum industry, wherever the attractive features of continuous liquid phase adsorption are required. Petroleum refiners will be interested in the cyclic adsorption process primarily for the manufacture of premium specialty products or chemical intermediates. Other modifications of the process are equally applicable in industries manufacturing fine chemicals, pharmaceuticals, and other high quality products where use of a highly selective separation process is required.

Summary

A cyclic adsorption process developed by the California Research Corp. for separation of chemical intermediates and specialty products from petroleum is described. This process has the following advantages:

1. It possesses wide flexibility with respect to type and boiling range of feed stocks.
2. Its use simplifies manufacture of many chemical intermediates from complex feed stocks.
3. The yield and purity of the products are considerably higher than are those obtained by conventional solvent distillation, extraction, or acid treating.
4. There is no stock loss and no sludge disposal problem.
5. The use of small sized adsorbent in fixed beds permits operation in smaller adsorption vessels, at higher liquid velocities, and at lower adsorbent replacement rates than are required in moving bed adsorption processes.
6. Automatic cyclic operation and optimum inter-zone recycling used in the new process reduces to the minimum the amount of adsorbent needed, the amount of stripping liquid that must be used, the amount of distillation that must be performed, and the amount of heat required.
7. Operation is continuous, and control of product purity is easily obtained by simple adjustment of cycle time and flow rates of recycle and strippant.

Acknowledgment

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Wash Solvent Requirements In Rotary Filter Operation

By E. J. REEVES
Technical Department, Refining Division
Magnolia Petroleum Co., Beaumont, Texas

THE COMMERCIAL APPLICATION of continuous rotary drum filters is steadily increasing throughout the petroleum and chemical industries. However, filtration theory for continuous equipment has lagged somewhat behind the actual mechanical development.

Two of the more important operating variables of interest to process and design engineers are (1) the effect of drum rotation speed on filter capacity and (2) the volume of wash that can be efficiently applied. Theoretical equations showing the relationship between drum rotation speed and filter capacity have been presented in a previous publication.[3] Further analysis of the general Poiseuille filtration equation permits derivation of the relationship between the volume of filtrate and the volume of wash liquid that can be efficiently applied (i.e., passed through the filter cake).

The general Poiseuille equation[2] for constant pressure filtration expresses the relation between time and filtrate as

$$\frac{dV}{d\theta} = \frac{AP}{\mu\,[\alpha(W/A) + r]} \quad \ldots\ldots (1)$$

Substituting the relation

$$W = wV \quad \ldots\ldots (2)$$

in Equation 1 and integrating for constant pressure filtration the following expression for total filtrate is secured:

$$\frac{\theta}{V/A} = \frac{\mu\alpha}{2P}\left(\frac{W}{A}\right) + \frac{\mu r}{P} \quad \ldots (3)$$

An equation similar to Equation 1 can be used to correlate the variables controlling the volume of wash liquid that can be applied. However, in this relation the term W/A is constant since the filter cake is already formed and the integrated form becomes:

$$\frac{\theta_w}{V_w/A} = \frac{\mu_w\alpha}{P}\left(\frac{W}{A}\right) + \frac{\mu_w r}{P} \quad (4)$$

In many cases, such as filtration of wax-oil-solvent mixtures in dewaxing of lubricating oils[3], and the filtration of refinery slop oils[1], filter base resistance is very small and can be neglected without encountering serious error. Equations 3 and 4 may thus be rewritten into the forms

$$\frac{\theta}{V/A} = \frac{\mu\alpha}{2P}\left(\frac{W}{A}\right) \quad \ldots\ldots (5)$$

$$\frac{\theta_w}{V_w/A} = \frac{\mu_w\alpha}{P}\left(\frac{W}{A}\right) \quad \ldots\ldots (6)$$

Substituting the value of W/A from Equation 5 in Equation 6 and simplifying the following relation is obtained:

$$\frac{V_w}{\theta_w} = \frac{\mu}{\mu_w}\,\frac{V}{2\theta} \quad \ldots\ldots (7)$$

In rotary drum filter operation the filtration is usually conducted at 50% drum submergence or on one-half of the drum surface and the wash applied only on the ascending quarter of the drum. No wash is applied on the portion of the drum descending toward the cake discharge blade. These operations are illustrated in Fig. 1. Since the cake is formed on one-half of the drum surface and the wash applied on one-quarter of the surface, the relation between washing and filtering time is:

$$\theta_w = \theta/2 \quad \ldots\ldots (8)$$

Substituting Equation 8 in 7 the following relation is obtained:

$$V_w = \frac{\mu}{\mu_w}\left(\frac{V}{4}\right) \quad \ldots\ldots (9)$$

The volume of filtrate V may be expressed as:

$$V = CY \quad \ldots\ldots (10)$$

and Equation 9 then becomes:

$$V_w = \frac{\mu}{\mu_w}\left(\frac{CY}{4}\right) \quad \ldots\ldots (11)$$

One of the most important applications of rotary drum filters is in lubricating oil dewaxing operations. In this process the waxy oil is diluted with a solvent before the wax is removed by filtration. To secure the relation between wash solvent and waxy oil charge to dewaxing filters, Equation 11 must be revised to correct for the dilution solvent in the filtrate.

Multiplying Equation 9 by $1 - F$ the relation between dewaxed oil and

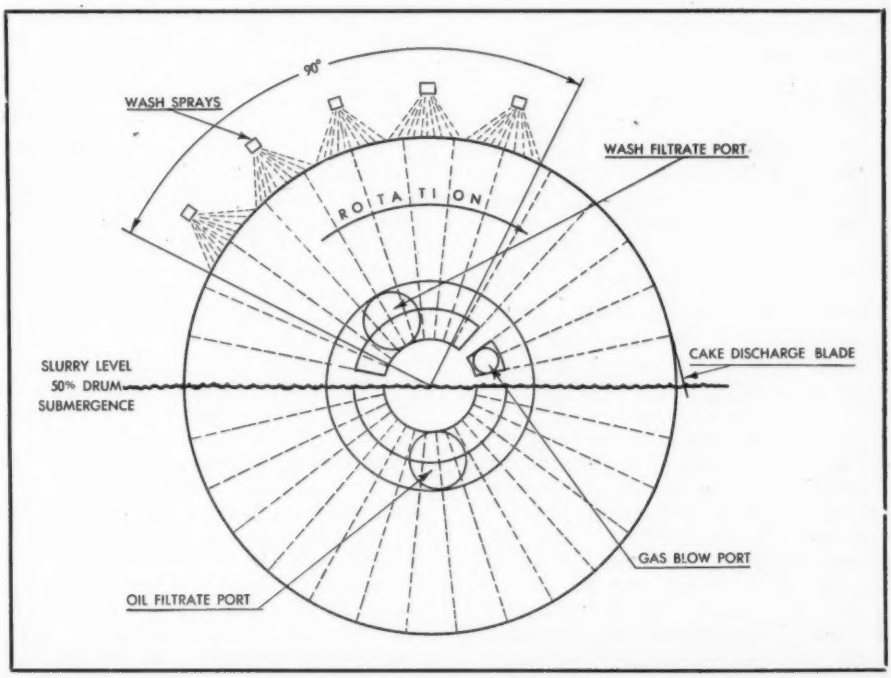

Fig. 1—Cross sectional diagram of a rotary drum filter, showing 50% drum submergence and application of wash solvent on ascending quarter of drum

TABLE 1—Effect of Yield, Solvent Dilution, and Filtrate Recirculation on Cold Wash Solvent to Charge Oil Ratio

Yield Fraction of Charge	Cold Wash Solvent to Charge Oil Ratio — Fraction of Solvent in Total Filter Charge				Filtrate Recirculation Ratio
	0.60	0.70	0.80	0.90	
0.90	0.60	0.81	1.22	2.46	0.0
0.80	0.58	0.78	1.20	2.44	
0.70	0.55	0.76	1.17	2.42	
0.60	0.53	0.74	1.15	2.40	
0.90	0.85	1.05	1.47	2.72	1.0
0.80	0.82	1.03	1.45	2.70	
0.70	0.80	1.01	1.43	2.68	
0.60	0.77	0.98	1.40	2.65	
0.90	1.10	1.31	1.72	2.97	2.0
0.80	1.07	1.29	1.69	2.95	
0.70	1.04	1.26	1.67	2.93	
0.60	1.02	1.23	1.65	2.90	
0.90	1.35	1.56	1.97	3.25	3.0
0.80	1.33	1.53	1.94	3.20	
0.70	1.31	1.50	1.92	3.15	
0.60	1.27	1.47	1.90	3.10	

wash solvent is secured. This expression is:

$$V_w = \frac{\mu}{\mu_w}\left(\frac{R}{4(1-F)}\right) \quad \ldots (12)$$

However,

$$R = CY \quad \ldots (13)$$

and therefore,

$$V_w = \frac{\mu}{\mu_w}\left(\frac{CY}{4(1-F)}\right) \quad \ldots (14)$$

In actual dewaxing operations the solvent dilution is not based on dewaxed oil but on the waxy oil. Correction of F for the wax fraction in the charge can be made from the equation

$$S = \frac{F}{F + \dfrac{1-F}{Y}} \quad \ldots (15)$$

Substituting the value of F secured from Equation 15 into Equation 14, the following expression is obtained:

$$V_w = \frac{\mu}{\mu_w}\left(\frac{C}{4}\right)\left(Y + \frac{S}{1-S}\right) \quad \ldots (16)$$

It has been found in operation of commercial dewaxing filters that composition of the dewaxed oil filtrate and the cold wash filtrate are very nearly equal. Thus, the viscosities of these filtrates are about the same and equation 16 can be simplified for most engineering calculations to the expression

$$V_w = \frac{C}{4}\left(Y + \frac{S}{1-S}\right) \quad \ldots (17)$$

For lubricating oil dewaxing filter operations it is common plant practice to recycle filtrate to the filter feed to reduce the percentage of solids in the mixture and, also, to decrease the thickness of the wax cake on the filter drum. In a previous publication[3] it was shown that recirculation of filtrate will not increase filter capacity and that this procedure should be used only when excess capacity exists. When excess filter capacity does exist, and filtrate recirculation is employed, the volume of wash solvent per volume of charge oil is increased and a corresponding increase in yield may be secured. Mathematical development of the cold wash ratio for various recycle ratios is given below.

The relation between the volume of wash and total filtrate is given in Equation 8. Substituting the relation

$$V = V_c + V_F$$

in equation 9, the expression becomes:

$$V_w = \frac{\mu}{4\mu_w}(V_c + V_F) \quad \ldots (18)$$

However, the volume of filtrate (V_c) from the waxy charge may be expressed as

$$V_c = \frac{CY}{1-F} \quad \ldots (19)$$

and the volume of filtrate (V_F) from the filtrate recycle is given by the relation

$$V_F = KC \quad \ldots (20)$$

Therefore,

$$V_w = \frac{\mu}{4\mu_w}\left(\frac{CY}{1-F} + KC\right) \quad \ldots (21)$$

Substituting the value of F secured from Equation 15 into Equation 21, and simplifying, the following relation is obtained:

$$V_w = \frac{\mu}{4\mu_w}(C)\left(Y + \frac{S}{1-S} + K\right) \quad \ldots (22)$$

Since in dewaxing operations the viscosities of the cold wash filtrate and the dewaxed oil filtrate are approximately equal, the ratio μ to μ_w approaches one and Equation 22 can be simplified to:

$$V_w = \frac{C}{4}\left(Y + \frac{S}{1-S} + K\right) \quad (23)$$

The wash solvent to charge oil ratio (V_w/C) for various yields, solvent dilutions, and filtrate recirculation ratios are given in Table 1.

Inspection of the data given in Table 1 shows that the cold wash solvent ratio is only slightly affected by yield and that the waxy oil solvent dilution and the filtrate recirculation ratio are the major variables. However, for a particular stock there is an optimum solvent dilution[4] that must be maintained to secure the maximum filter output of solvent-free dewaxed oil. Thus, the only variable actually affecting the wash solvent to charge oil ratio is the filtrate recirculation ratio.

Conclusions

Specific conclusions developed in this paper for continuous rotary filters operating at 50% drum submergence and with wash solvent applied only on the ascending side of the rotating drum, are as follows:

1. For the simple removal of solids from a liquid the volume of wash that can be applied is given by the relation:

$$V_w = \frac{\mu}{\mu_w}\left(\frac{CY}{4}\right)$$

2. In the dewaxing of lubricating oils where a dilution solvent is employed the wash volume is expressed as

$$V_w = \frac{\mu}{\mu_w}\left(\frac{C}{4}\right)\left(Y + \frac{S}{1-S}\right)$$

3. When filtrate recirculation is used in solvent dewaxing filtration the wash volume is given by the equation

$$V_w = \frac{\mu}{\mu_w}\left(\frac{C}{4}\right)\left(Y + \frac{S}{1-S} + K\right)$$

4. Filtrate recirculation, as shown in another paper[4], decreases filter capacity in that the quantity of fresh waxy charge which can be processed is reduced. However, in numerous cases some excess filter capacity exists and recirculation of filtrate may be advantageously employed. Use of filtrate recirculation to utilize this excess capacity will result in somewhat higher cold wash solvent to charge oil ratios and may, therefore, increase the recovery of dewaxed oil from the filter cake.

Acknowledgment

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Nomenclature

V = Volume of total filtrate.
A = Area of filtering surface.
θ = Time of filtration.
μ = Filtrate viscosity.
α = Average specific cake resistance.
W = Weight of dry cake solids.
r = Filter medium resistance.
P = Pressure drop through filter medium and cake.
w = Weight of dry cake solids per unit volume of filtrate.
V_w = Volume of wash filtrate.
θ_w = Time wash solvent applied.
μ_w = Viscosity of wash filtrate.
C = Slurry or waxy oil charge to filter.
Y = Yield of solid or wax-free material.
E = Solvent-free dewaxed oil filtrate.
F = Fraction of solvent in filtrate.
S = Fraction of solvent in waxy charge.
V_F = Volume of filtrate recirculation.
V_c = Volume of filtrate from waxy oil charge.
K = Filtrate recirculation to charge oil ratio.

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Catalytic Effects in Suspensoid Cracking

By C. H. CAESAR, Technical and Research Dept.
Imperial Oil Ltd., Sarnia, Ontario

Research which has been conducted in the Sarnia laboratories of the Imperial Oil Limited on the subject of suspensoid cracking, has been essentially of the applied type in that it has been directed toward the development of a practical process with immediate applications in mind. Descriptions of pilot plant and refinery units, and of the general results of suspensoid cracking have appeared in previous publications [1-6]. It is the purpose of this paper to discuss the fundamental nature of the process, especially with regard to its catalytic aspects. Since the experiments were concerned with feed stocks and operating conditions typical of refinery practice, the reactions involved were extremely complex and the mehods of testing were largely of the empirical type which have been developed in the industry. As a consequence, the study is essentially of a qualitative rather than a quantitative nature.

SUSPENSOID cracking is a process for the conversion of petroleum hydrocarbons in which the feed stock, together with a small amount of catalyst or contact agent, is charged to a reaction coil of a type familiar to the industry for pyrolytic cracking.

Feed stocks may range from naphthas to high-boiling gas oils or any mixtures of such components, while typical operating conditions are: coil outlet temperatures 1030°-1130° F; coil outlet pressures 200-1,000 psig.; feed rates 6-14 V/V/Hr. (volume of cold feed per volume of reaction coil above 800° F. per hour) and catalyst concentrations ranging from 2-30 lbs./bbl. of feed. Water may be injected with the heavier feed stocks to aid in vaporization without which coking of the coil occurs.

The suspensoid process, therefore, differs from conventional pyrolytic cracking in that a catalyst is employed and temperatures appreciably higher than those attainable in purely thermal operations are possible, thus permitting gasolines of higher antiknock rating to be produced. It differs from conventional catalytic cracking processes in that the concentration of catalyst is very much smaller (in the order of 0.1% of that used in Fluid catalytic cracking) and that operating pressures are much higher.

Effect of Catalyst

In addition to the primary reaction of carbon bond scission, secondary reactions such as isomerization, polymerization and condensation are extremely important in catalytic cracking processes. Studies by Thomas, Greensfelder and others who have investigated the reactions of pure compounds in fixed bed catalytic cracking experiments, have demonstrated that typical cracking catalysts have distinctive effects, some of which are as follows:

1) The catalyst exerts a differential effect on the rate of carbon bond scission. Large molecules are cracked much more rapidly than small ones of the same molecular type.[7] As a consequence, light naphthas charged to Fluid, Thermofor, or Houdry cracking units are recovered in the products virtually unchanged unless unusually severe conditions are employed.

2) In contrast to thermal cracking where the rupture of the molecule takes place at almost any carbon bond, according to the laws of chance and frequently near the end of the carbon chain, cracking catalysts favor the splitting off of groups of three or more carbon atoms.[7] As a consequence there is relatively little dry gas (particularly materials lighter than propane) and a very high percentage of butanes in the cracked products.

3) Naphthenic compounds are cracked more readily than paraffinic compounds [8], which is the reverse of thermal cracking experience and explains the relatively high pour points of the cycle stock from the above processes.

4) A high percentage of isoparaffins are found in the catalytically cracked gasoline.

5) It has been found that cracking catalysts are active polymerization agents.[9] Condensation reactions between olefines and aromatics have also been demonstrated.[10] Such reactions may result in the formation of cyclic compounds.

As has been explained, direct evidence of the above reactions is difficult to acquire from suspensoid cracking experiments on refinery type feed stocks. In view of the difficulties in obtaining "blank" runs at high conversions, the catalytic effects observed in suspenoid cracking may be evaluated by comparing the results secured when using good versus poor cracking catalysts. The data shown in Table 1 are typical of the results obtained when cracking mixed naphthas and gas oil feeds with catalysts of different activities in the suspensoid pilot plant. A study of these runs leads to the following observations:

i) The most important difference between two catalysts is the ability of the silica alumina to impart higher octane numbers to the cracked gasoline.

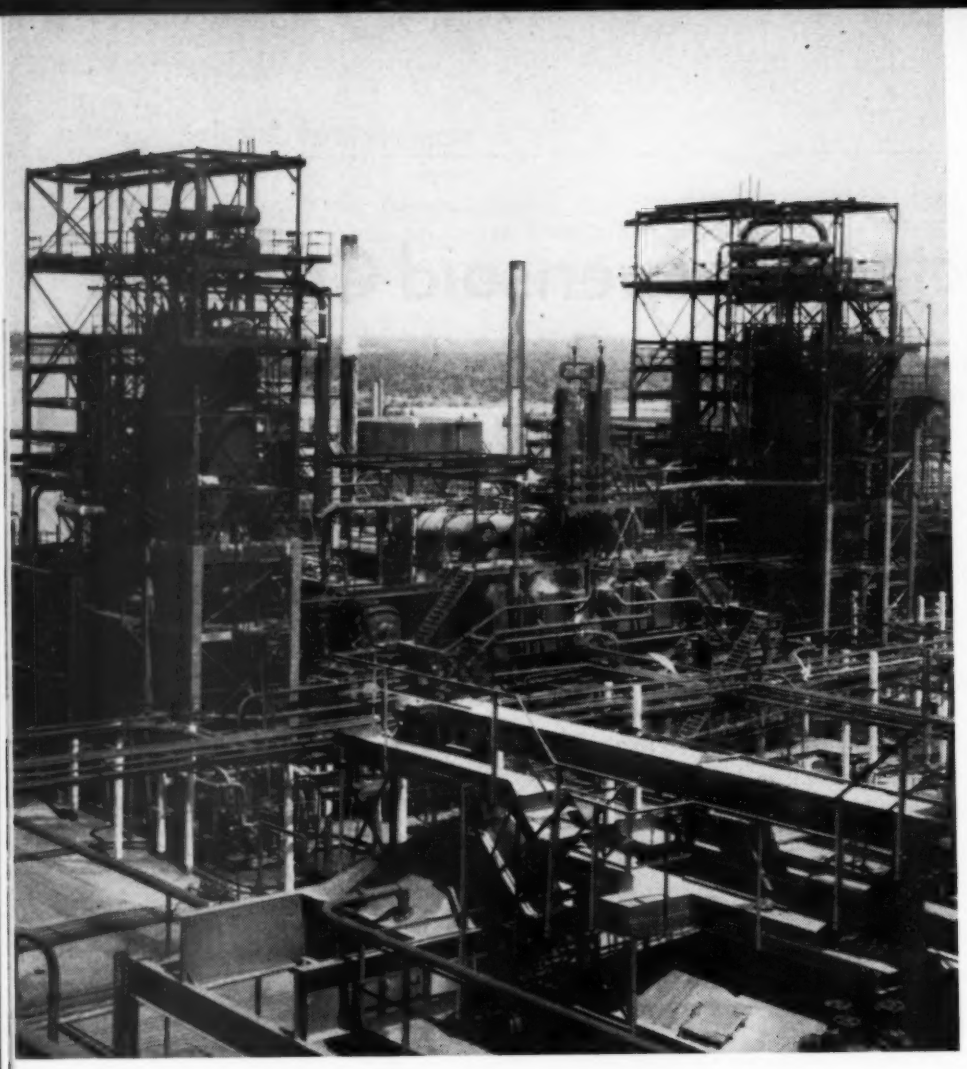
ii) Since the bromine numbers of the gasolines differed by only 10 cg./g. and the aniline points were almost the same, the improvement in octane rating should not be attributed simply to the production of more olefines or aromatics in the gasoline.

Meet the Author

Dr. Cameron H. Caesar graduated from the University of Toronto in 1933 with a B. A. degree in Chemistry, Mineralogy and Geology. From the time of his graduation until the fall of 1934, he worked in the Technical and Research Laboratory of Imperial Oil Ltd. at Sarnia.

From 1934 to 1936 he attended the University of London, England, where he carried on post-graduate work, at the end of which he obtained the degree of Ph. D. in Chemistry.

He rejoined the staff of the Technical and Research Department at Imperial in 1937, and since that time has spent the major portion of his time carrying out research work on catalytic cracking. In 1948 he was made Chief Research Chemist.



Suspensoid Cracking

Two of a group of three old thermal coils at Imperial Oil's Sarnia refinery which have been converted to suspensoid operation

A demonstration experiment which clearly shows secondary reactions, including hydrogen transfer reactions, is illustrated in Table 3 in which butanes, butylenes and straight run naphtha were treated in the presence of silica alumina catalyst under conditions too mild to result in any appreciable cracking. In this particular experiment the weight recovery was 93% and the range of product yields shown represents the extreme limits obtained by assuming the loss to be in the feed or in the gaseous products. The results show that the total butane fraction which was recovered amounted to more than that charged, plus the small fraction which might have been cracked from the naphtha charge. The n-butane recovered was essentially the amount charged, while isobutane accounted for the whole of the net increase! The decrease in isobutylenes during the experiment was more than enough to account for the results by a hydrogen transfer mechanism. The gain in the quantity of pentanes and heavier hydrocarbons is clear evidence of the conversion of butylenes into heavier material, which needs no further comment.

A similar experiment, performed under identical conditions, but with benzene substituted in place of the naphtha in the feed, gave less isobutane in the product, suggesting that the naphtha had served as a hydrogen donor, but an interesting feature of the experiment with benzene was that appreciable quantities of toluene, xylenes and heavier aromatics and also some naphthenes

An increase in the percentage of isoparaffins may also be indicated.

iii) The lower ratios of olefines to paraffins in the light hydrocarbon fractions obtained when using the silica alumina catalyst suggest that this material has a higher activity for the conversion of the light olefines. The higher coke production also points to more extensive polymerization with this catalyst.

iv) The ratio of gasoline to dry gas does not appear to be sensitive to the catalyst employed.

v) The higher yield of butanes produced when using the more active catalyst shows a trend in line with catalytic effects discussed above.

vi) While there is some evidence that higher temperatures are required to produce a given conversion to dry gas when using less active catalyst, the data are not entirely consistent on this point.

In the case of naphtha feed stocks it is possible to observe the effects of the catalyst by direct comparison with conventional non-catalytic reforming runs. Typical results are shown in Table 2. As would be anticipated from the reduced effectiveness of catalysts on low molecular weight feed stocks referred to in the literature, the differences between thermal and suspensoid reforming results are not large, but they are quite distinct. The effect of the catalyst is to increase the octane number of the gasoline, reduce the percentages of olefines in the light hydrocarbon fractions and increase the production of butanes. The increase in butane yield is largely at the expense of the heavier gasoline fractions, so that on the basis of gasoline yields of constant vapor pressure, there is no net gain for the catalytic operation in the yield of gasoline for a given octane number. On the basis of gasoline plus total butane yields, however, suspensoid reforming does show an advantage.

TABLE 1—Comparison of Catalysts

Suspensoid Cracking 40/60 Mid-Continent Naphtha and Gas Oil Feed.

Feed Rate: .....9 V/V/Hr.
Catalyst Concentration:.10 lbs./bbl.
Temperature: ....Approx. 1065° F.
Pressure: .....600 psig.

Catalyst	Bauxite	Silica-Alumina
Conversion to Dry Gas, Wt. %.	18	18
Gasoline (400° FBP 10# RVP), Vol. %	59	59
Heating Oil (600° FBP), Vol. %	12	11
Tar (600° F.), Vol. %	9.0	9.0
Excess Butane (over 10# RVP), Vol. %	4.0	5.5
Coke (as carbon), Wt. %	0.3	0.8
Ethane, Vol. %	8.9	9.3
Ethylene, Vol. %	3.9	3.4
Propane, Vol. %	7.4	8.2
Propylene, Vol. %	7.0	6.2
Butanes (total), Vol. %	4.3	5.2
Butylenes (total), Vol. %	5.6	5.7
Gasoline:		
Motor Octane Number Clear..	73.4	75.0
Research Octane Number Clear	83.5	86.0
Aniline Point, ° F.	76	72
Bromine Number, cg./g.	70	80

TABLE 2—Effect of Silica Alumina Catalyst in Suspensoid Reforming

Feed:...53.5° A.P.I. Mid-Continent Naphtha, 150-440° F. boiling range
Feed Rate: .....9 V/V/Hr.
Catalyst Concentration:.10 lbs./bbl.
Temperature: .....1065° F.
Pressure: .....800 psig.

Catalyst	Nil	Silica-Alumina
Conversion to Dry Gas, Wt. %..	20	20
Gasoline (400° FBP 10# RVP), Vol. %	70.5	68.3
Excess Butane (over 10# RVP), Vol. %	4.1	6.5
Tar, Vol. %	5.9	5.2
Coke (as carbon), Wt. %	nil	0.7
Ethane, Vol. %	9.5	9.65
Ethylene, Vol. %	3.1	2.8
Propane, Vol. %	8.6	8.9
Propylene, Vol. %	6.6	5.9
Butanes (total), Vol. %	5.0	7.3
Butylenes (total), Vol. %	5.6	5.7
Gasoline:		
Motor Octane Number Clear..	73.9	74.7
Research Octane Number Clear	84.6	85.4
Aniline Point, ° F.	79	82
Bromine Number, cg./g.	59	60

TABLE 3—Conversion of Butylenes

Feed: Butanes, Wt. % 18.3
Butylenes, Wt. % 25.3
Naphtha, Wt. % 56.4

Bath Temperature: .....900° F.
Coil Pressure: .....800 psig.
Silica Alumina Catalyst:.....10 lbs./bbl.

Products	Total	Estimated from naphtha	Difference from butane-butylene charge
	(Wt. % on total feed)		
Dry Gas	3.3- 3.7	2.3	1.0- 1.4
Butanes	22.8-26.9	0.7	22.1-26.2
Butylenes	6.8- 6.5	0.6	6.2- 5.9
Gasoline (C_5—430° F.)	62.0-59.0	52.0	10.0- 7.0
Heavy Fuels (above 430° F.)	4.0- 2.9	0.3	3.7- 2.6
Coke	1.1- 1.0	0.5	0.6- 0.5

were produced. Approximate conversions were calculated to be as follows:

Butylenes converted to lighter products	4 wt. %
Butylenes converted to isobutane	13 wt. %
Butylenes converted to benzene alkylates	12 wt. %
Butylenes converted to polymer	40 wt. %
Butylenes unconverted	31 wt. %
	100 wt. %
Benzene converted to alkylate	15 wt. %
Benzene converted to naphthenes	12 wt. %
Benzene unconverted	73 wt. %
	100 wt. %

Although the primary reactions of carbon bond scission are largely determined by the thermal conditions in suspensoid cracking, it is evident that the catalyst plays an effective role in secondary reactions which are most important in determining product quality. This is especially remarkable in view of the small percentage of catalyst employed, and the relatively short contact times, in the order of 20 sec. of residence in the reaction zone.

The catalyst also plays an important part in determining the operability of the process. While the point at which excessive coke deposits form on the walls of the cracking coil is governed by many variables, including conversion feed type, feed rate, the partial pressure of the hydrocarbons, the presence of water vapor, the linear velocity in the coil and the many aspects of furnace design, it has been observed in refinery practice that a failure of the catalyst injection equipment results in a shutdown of the unit within a matter of minutes.

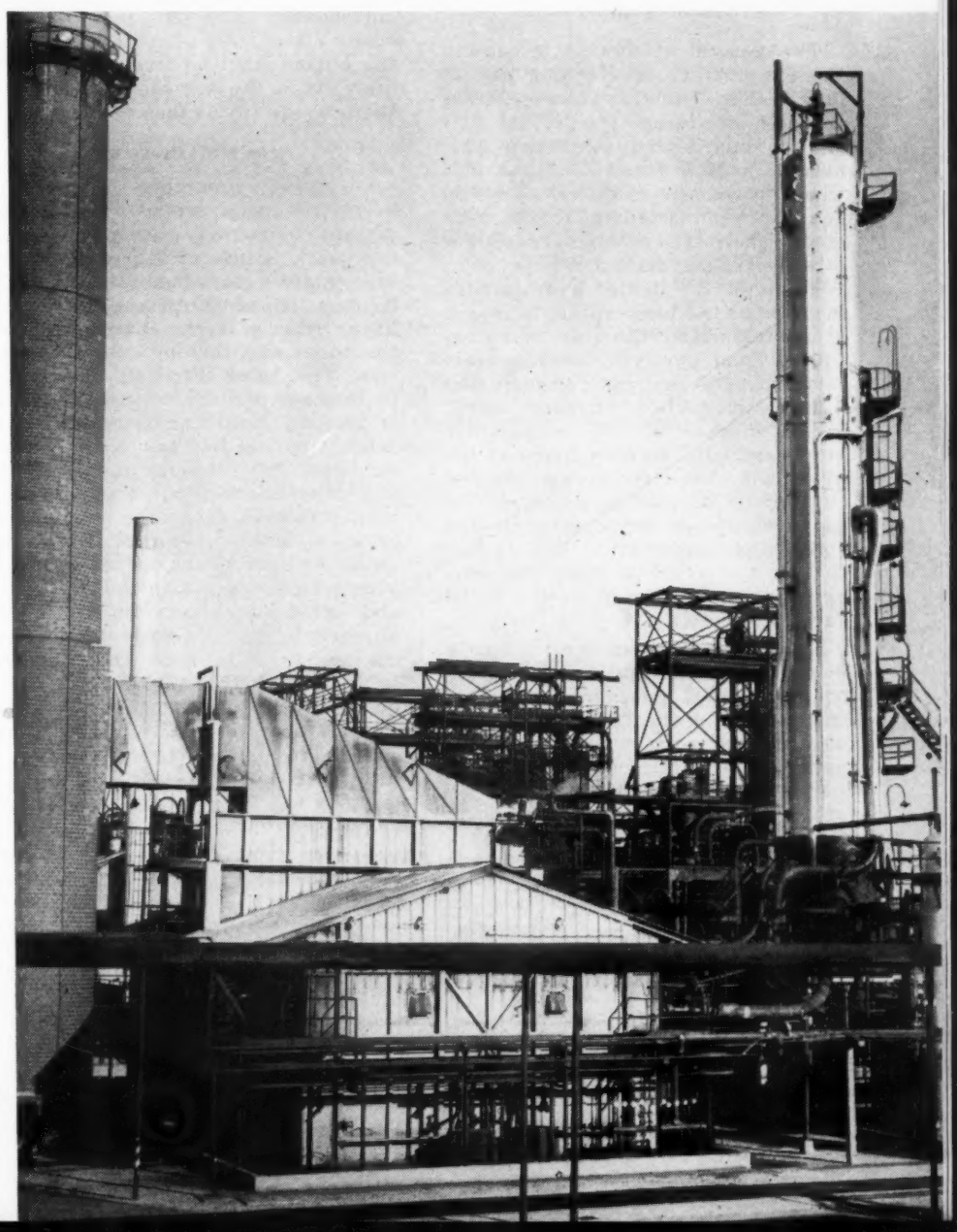
It is generally considered that the production of coke in vapor phase cracking operations is the result of complex reactions involving the separation of a small amount of a liquid phase composed of high-boiling polymers. The liquid polymers coat the walls of the tubes and are subjected to high temperatures for prolonged periods as a result of which further decomposition and polymerization reactions take place with the ultimate production of coke.

It is therefore apparent that in the suspensoid process the catalyst could be effective in improving operability by (a) scouring the surface of the coil in such a manner as to remove carbonaceous deposits and (b) adsorption of high-boiling polymers on the surface of the catalyst before a separate liquid phase appears. It is probable that both mechanisms take place since it has been shown that an inert material such as silica flour does contribute, to some extent, in improving operability.

This rudimentary theory accounts for the improvement in operability which may be obtained by decreasing the partial pressure of the hydrocarbon feed or by increasing the concentration of catalyst charged to the coil. However, it does not entirely account for the coke deposits which are produced on a catalyst surface.

It has also been found that the coke on the catalyst is influenced to only a slight extent by the boiling range of the feed stock, which again, is contrary to expectations. The percentage of coke on the catalyst is increased by increasing the operating pressure. This may correspond to the increased adsorption which would be expected upon physical chemical grounds or it may be a consequence of longer residence time of the catalyst in the coil at higher pressures.

Finally, it is noteworthy that the deposits of coke on the catalyst are not influenced by the concentration of catalyst which is used. These observations lead to the conclusion that at least an appreciable fraction of the coke deposits are a result of cracking reactions directly associ-



Imperial also operates at Sarnia a new coil (right) designed specifically for the suspensoid process

TABLE 4—Effect of Temperature

Feed: .....40% Naphtha, 60% Gas Oil (Mid-Continent)
Feed Rate: .....9 V/V/Hr.
Catalyst: .....Silica-Alumina, 10 lbs./bbl.
Coil Pressure: .....600 psig.

Coil Outlet Temperature, ° F.	1040	1100
Product Distribution:		
Dry Gas (Propane and lighter), Wt. %	14.8	22.5
Gasoline (400° FBP 10# RVP), Vol. %	62.0	54.0
Heating Oil (600° FBP), Vol. %	12.8 (24.5° API)	9.3 (20.7° API)
Tar (600° F.), Vol. %	9.1 (4.4° API)	8.9 (0.7° API)
Excess Butane (over 10# RVP), Vol. %	4.3	7.1
Coke (as carbon), Wt. %	0.8	0.8
Hydrogen and methane, Wt. %	2.1	4.7
Ethane, Vol. %	6.8	13.0
Ethylene, Vol. %	3.0	4.0
Propane, Vol. %	7.2	9.6
Propylene, Vol. %	5.7	6.8
Butanes (total), Vol. %	5.4	5.6
Butylenes (total), Vol. %	4.8	6.6
Gasoline:		
Motor Octane Number Clear	74.0	76.6
Research Octane Number Clear	84.4	88.5
Aniline Point, ° F.	84	63
Bromine Number, cg./g.	73	87

ated with the catalyst surface. The adsorption of heavy polymer which makes up the rest of the deposit and which is directly related to operability is, therefore, not necessarily proportional to the total coke production on the catalyst.

Effect of Temperature

The general effects of increasing the temperature of cracking are illustrated in Table 4 which presents data for an average type of 41° API gravity mixed feed containing 40% natural naphthas and 60% gas oils. Quantitative effects differ, as would be expected, according to the feed stock charged and the values of other operating variables.

Yields of the lighter hydrocarbons increase as the temperature is raised, at approximately the rate to be expected from pyrolytic cracking correlations. The dry gas (propane and lighter) production increases about 1.3% for each 10° F. temperature increment. (It has been found in the pilot coil that dry gas production is a more reliable measurement of the severity of cracking than the coil outlet temperature, and forms the most convenient basis for estimating conversions of feed to the various products.)

The decrease in gasoline yield with increasing temperature is a normal consequence of reforming the naphtha portion of the feed stock. Likewise, the decrease in gas oil yield parallels pyrolytic cracking experience. Yields of normally liquid products are very dependent upon the composition of the feed stock, as discussed below. In the example given, the yield of tar appears to be independent of temperature but the change in gravity shows this to be a result of compensating reactions —cracking versus polymerization and condensation.

It is evident from the decrease in aniline point and relatively smaller increase in bromine number that the improvement in gasoline octane number with temperature is a consequence of a relative increase in the percentages of both aromatics and olefines in the gasoline at the expense of paraffinic constituents.

The effect of temperature in increasing the percentage of olefines in a given fraction decreases in the lighter cuts, the propane-propylene cut showing essentially no change in composition with temperature, while the ethane-ethylene fraction shows a decrease in the per cent ethylene as the temperature is increased.

Effect of Pressure

Operating pressures appreciably below 200 psig. are avoided in the present commercial suspensoid cracking coils because of the tendency of the catalyst to erode return bend headers. Higher pressures lower the linear velocity of the charge through the tubes and thereby decrease erosion. They also offer an advantage in furnace capacity when heat input is limiting since the increased residence time in the coil compensates for lower coil temperatures to effect a given conversion. Furthermore, high pressures favor the production of more stable gasolines. However, an upper limit to the operating pressure, which varies with the feed type and other operating conditions, is imposed by the tendency to deposit coke on the tube walls and headers. In the latter, the coke deposits frequently result in impingement of the catalyst on the metal walls with localized erosion as a consequence.

As in conventional pyrolytic cracking, the use of high pressures tends to suppress the yields of light olefines. At a given conversion to dry gas, yields of gasoline from the 40/60 mixed feed discussed above are approximately 1% higher when operating at 600 psig. than at 400 psig. Evidence of an octane advantage for operations at high pressures is, however, inconclusive.

Feed Stock Type and Rate

Gasoline, heating oil, and tar yields are particularly affected by the feed stock composition. As would be expected, the higher the percentage of the feed which boils within a given range of temperatures, the greater is the yield of product boiling in the same range. Product distribution does not appear to be affected by the type of crude from which the feed stock was derived, but the less paraffinic feeds produce gasolines of higher octane numbers than the other types, presumably due to a correspondingly low percentage of normal paraffins in the cracked gasoline. This effect was illustrated in a previous publication.(5)

The octane number requirements of the newer high compression engines are such that it is becoming imperative to decrease the percentage of the natural naphtha in the gasolines produced in most refineries. In cases where suspensoid cracking units are available, it is advantageous to accomplish this by charging the natural naphtha along with the gas oil cracking coil feed, rather than by reforming the naphtha separately. An appreciably higher gasoline yield is obtained from the mixed feeds, when cracking to a given pool octane number, due to the fact that the gas oil may be cracked more severely and the naphtha correspondingly less severely in the mix than is feasible when processing these stocks separately in a suspensoid unit. There is also some evidence of chemical interaction of the components in the coil which contributes to the advantage for this procedure.

Conclusions

It is evident that suspensoid cracking has features in common with both conventional pyrolytic and catalytic cracking processes. Product distribution follows patterns which are largely determined by thermal reactions, modified however by reactions typical of those promoted by cracking catalysts. Secondary reactions which are preferentially favored by the catalyst include isomerization, hydrogen transfer, polymerization and intermolecular condensations. Reactions of the catalysts with materials which tend to form coke in the cracking coil are extremely important from an operability standpoint.

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Sulfur from Sour Refinery Gases

Hydrogen sulfide is extracted from sour refinery gases in plants adjacent to Long Beach, Calif. in the new sulfur plant of Hancock Chemical Co. The H_2S is absorbed in diethanolamine (DEA) at the individual refineries, and the H_2S-rich DEA solution then returned to the chemical plant through pipelines. At the chemical plant it is steam-stripped to remove H_2S, and the regenerated DEA solution pumped back to the refineries for re-use. The H_2S is converted to sulfur by a modified Claus process, in which part of the H_2S is burned to sulfur dioxide, which is then reacted with the unconverted H_2S to yield elemental sulfur of 99.8% purity.

SULFUR compounds were found to exist in the atmosphere over the Los Angeles Basin during the early years of World War II after catalytic cracking became established and the rubber 'plantations' were placed in operation.

At that time, the peculiar eye irritants were considered to be a product of butadiene plants, and large amounts of money were expended to prevent the escape of any fumes originating in these units. After an extensive survey of the situation, however, the cause of what is locally termed 'smog' was found to be in the many manufacturing plants in Los Angeles and the surrounding territory, and not all of the disagreeable content of the contaminated atmosphere was from petroleum refineries. The refiners as a whole started investigations of their own, and this led to the discontinuance of acid sludge burning, which removed a considerable part of the SO_2 from smoke stacks.

When California petroleum products are 'hit hard' in thermal cracking units and when charge stocks are processed by catalytic cracking, the sulfur in the oil is converted largely to hydrogen sulfide. As a result the sour gas, when used in oil heaters and boiler plants, supplied a great part of the SO_2 in the atmosphere. This resulted in smog when the air conditions were ideal for a combination of fog and smoke.

So far as the oil refineries are concerned, a concrete means of eliminating the unpleasant situation was considered which entailed the conversion of hydrogen sulfide into elemental sulfur. Only one successful method had, at that time, been established to remove hydrogen sulfide from the sour gas, and only one had been developed for the successful conversion of sulfur compounds to elemental sulfur. This method had been "played with" for perhaps a half century in England and particularly by the Germans who used the Claus Kiln.

At the time the Germans were "relieved" of their holdings in the Middle East, they left one or two small plants standing which had been employed for the manufacture of sulfur from sour gases, which were modified versions of the Claus process, and an English concern, Simon & Carves, Ltd., acquired possession of them.

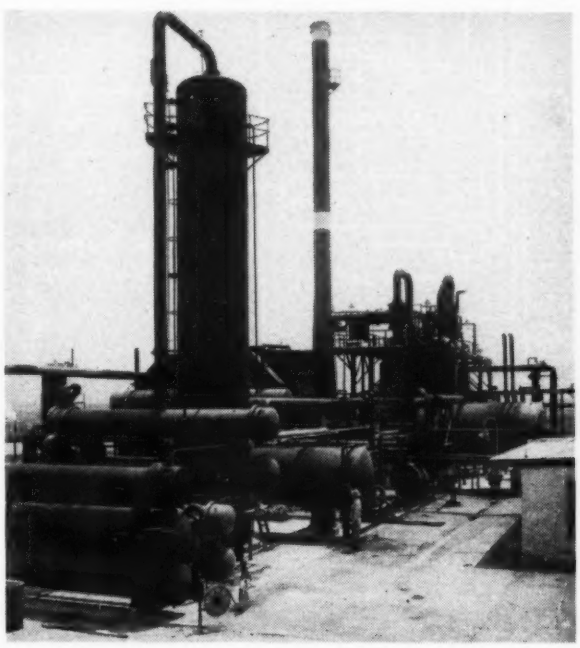
At the time that conditions were maturing for such a plant in southern California, Hancock Chemical Co., a subsidiary of Hancock Oil Co. of California, along with engineers of E. B. Badger & Sons, sent representatives to obtain all of the available information relative to the operation of such units. This was preliminary to the construction of an elemental sulfur plant near Long Beach to process hydrogen sulfide extracted from sour gas in adjacent refineries. In the late summer of 1948, contracts were made with suppliers of H_2S and with Badger to build a plant having a capacity of 50 long tons at a convenient distance from the Watson refinery of Richfield Oil Corp.

Hydrogen sulfide is extracted from refinery sour gas with diethanolamine, supplied to the refineries by Hancock Chemical Co. through pipe lines at adequate pressure for the extraction of H_2S in the refinery DEA absorbers. The pressure on the systems is sufficient to return the rich solution to the chemical plant without intermediate or additional pumping and handling, except by instrument control of the flow of solution to maintain the required ratio between the solution and the sour gas being treated. The circulation is continuous and the rich solution is processed to remove the H_2S in the chemical plant.

The absorption equipment employed by the refiners follows a more or less conventional pattern and the operation of the columns and scrubbers is similar to the operation of such equipment elsewhere. Likewise, the H_2S stripper, or DEA re-activation still at Hancock Chemical Co. is quite similar to such strippers included in sour gas treating plants in other sections of the country which employ DEA as the extracting solution.

Adequate instrumentation is in-

This Month's Cover Picture



General view of the new Hancock Chemical Co. sulfur plant. Stripping column, exchangers and condensers in foreground handle H_2S-rich DEA solution (diethanolamine) received from adjacent refineries, removing H_2S for conversion to sulfur (background)

stalled at the refineries and at the chemical plant to control the flow of the solution, the temperature of re-activation and the pressure required to conduct the hydrogen sulfide vapors from the stripper to the elemental sulfur plant. Evaporating pressures on the re-activating still are low, and the overhead stream temperatures are controlled so that water vapor and DEA as a mist, if any, are condensed and received in proper accumulator and vessels to insure an uncontaminated stream of hydrogen sulfide, as well as to conserve the DEA solution. The pressure required to conduct the hydrogen sulfide vapors from the stripper and auxiliary vessels is about 5 psig. This pressure has been found high enough to carry the vapors through the various stages of conversion as, in the final reaction, practically all of the feed vapors are converted into elemental sulfur.

The process at Hancock Chemical Co. is a modernization of the Claus kiln employing three combustion chambers where the sulfur compounds are burned with a deficiency of air. The major portion of the vapors enter a waste heat boiler where the temperatures of combustion are employed to generate steam which, in turn, is used for pumps, processes, preheaters and the like. Air at relatively low pressure is supplied to the burners so that the process of combustion is above atmospheric pressure, in order that the product of combustion will be forced into the subsequent sections of the plant. Such equipment as required is installed to separate the converted sulfur from the stream of vapors and to divert the liquid product through pipe lines into an underground receiver. The remaining hydrogen sulfide is directed to secondary burners to complete the conversion.

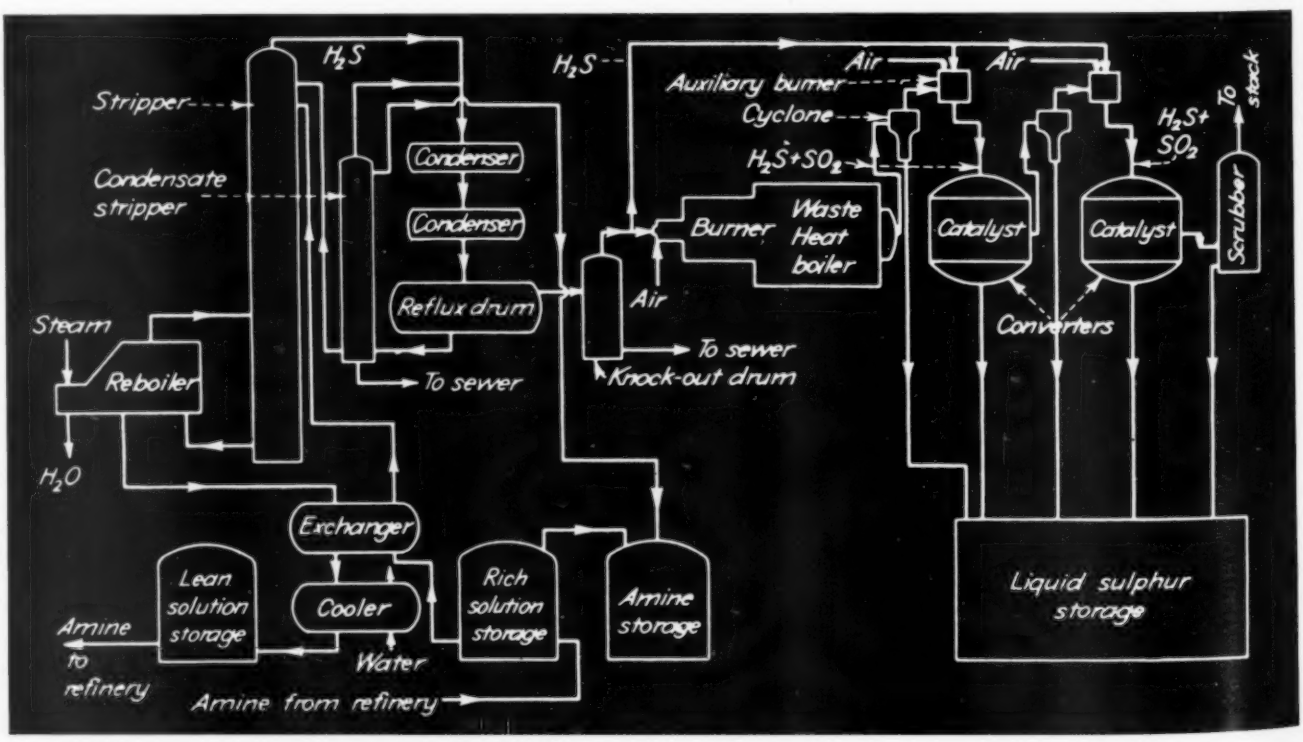
Two catalytic chambers are employed in the plant, operating in series so that part of vapors which are not converted in the first chamber will be changed into elemental sulfur in the second. All of the product, 99.8% pure elemental sulfur, is collected from the various draw-offs into the underground receiver, where it is held at a temperature necessary for liquid sulfur. It is periodically pumped from this receiver into insulated tanks on transport trucks for shipment to Stauffer Chemical Co.

As in all new plants, and particularly in plants employing new processes, problems have been encountered which were not anticipated. For example, it was assumed that as much as 0.5% of contaminants, such as petroleum vapors, would not create an adverse operating condition. However, after starting the plant, it was soon discovered that the above percentage of contaminants in the form of hydrocarbon vapors would be only partially burned, resulting in the deposition of a hard carbon formation on the burner tips. Removal of this deposit is accomplished only during a shutdown and tearing down the burner assembly. On less than 0.2% of hydrocarbon vapors in the hydrogen sulfide gas, only a slight deposit is noticed which does not retard the operation of the burners. However, the refiners who supply the hydrogen sulfide vapors have installed adequate equipment in their plants to eliminate contact with refinery vapors carrying products which might be included in the return rich DEA solution.

Several advantages are apparent in the refineries that extract hydrogen sulfide from the sour gases. Workmen who must maintain and operate equipment adjacent to furnaces formerly fueled with sour gas, now can work in comfort even when the wind drift blows stack gases towards the units. Corrosion of equipment, due to sulfur compounds, is eliminated largely by using a sweet fuel for furnaces and gas engine driven compressors. The atmospheric condition has been cleared remarkably and the "smog" forms at less frequent intervals, even if plain fog envelops the metropolitan area of Los Angeles.

Earlier Article

An earlier article in the April PETROLEUM PROCESSING gives additional information on the west coast Smog problem and what part the petroleum industry is playing in efforts to remedy it—"The Petroleum Industry and Smog," April, 1949, pg. 391.



Flow diagram of Hancock Chemical Co. plant for converting refinery H_2S to elemental sulfur

Short Cut Process Design to Increase Propane Recovery in Gasoline Plants

By ALAN S. GLENDENING and CHARLES F. SANDERSON
Sanderson-Glendening, Consulting Engineers, Houston

Article 7: Gas Fractionation

This month the authors discuss the gas fractionation process as applied to natural gasoline and cycling plant operations. The process consists of recovering the valuable constituents of natural gas by low temperature fractional distillation, rather than by contacting the gas with absorption oil. Flow diagrams of the process are shown, and the effect of various operating variables discussed. A following article will discuss the methods of calculation involved in the design of gas fractionation facilities.

GAS fractionation has been used frequently to recover valuable components from waste refinery gases, and hence is sometimes referred to as vapor recovery or rectification. The same application to wet natural gases has been infrequent, however, partly because of certain limitations of applicability and partly (in the authors' opinion) because of unfamiliarity with the system on the part of plant operators. As operators become better acquainted with its advantages, and if the trend toward high propane (and possible ethane) recovery continues, the gas fractionation plant may become quite common.

The most obvious merit of this type of plant is its simplicity. This factor becomes of particular significance when high propane recovery is desired since (as has been indicated in the previous articles of this series) the oil absorption plant must undergo several complicating revisions in order to obtain high recovery rates at moderate costs. Except for its refrigeration and dehydration sections (to be discussed shortly) the gas fractionation process is shown in its entirety in Fig. 1.

The process is as follows: wet gas is chilled and fed to a fractionating column called a "recovery tower" where it is contacted with cold re-

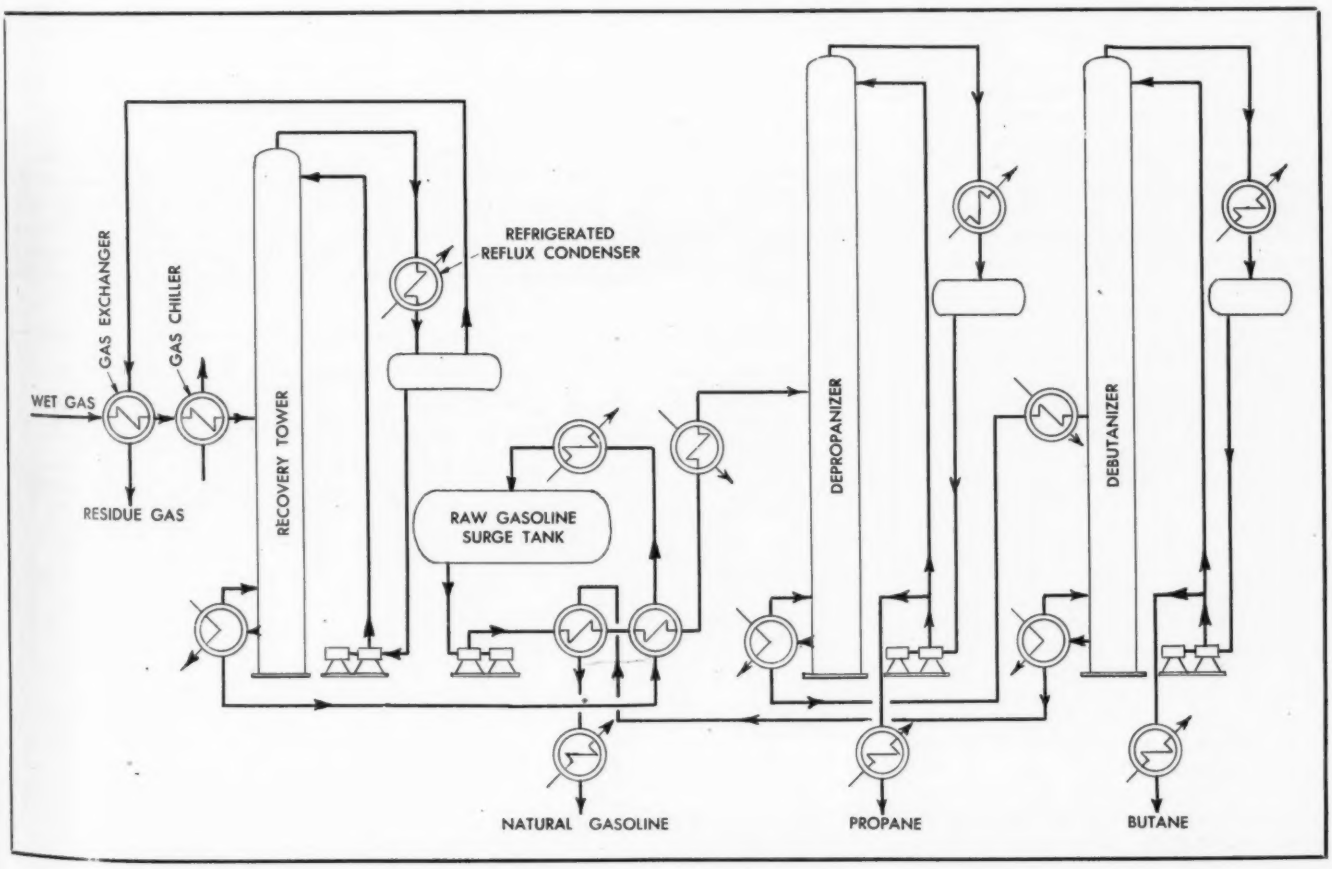


Fig. 1—Typical gas fractionation system

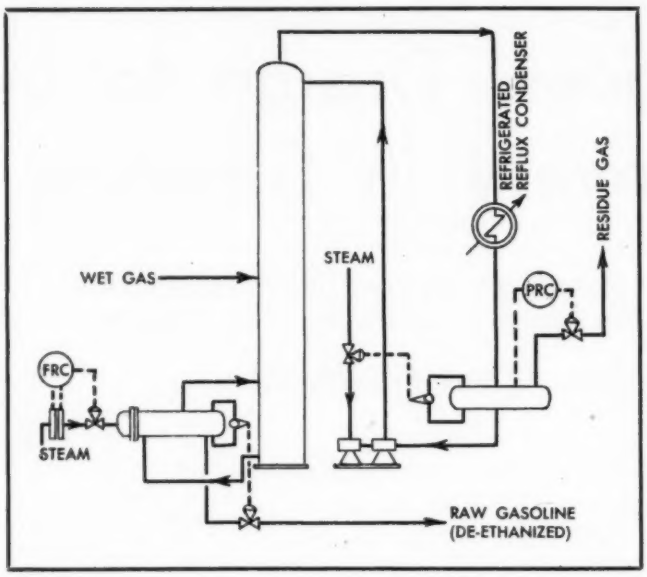


Fig. 2 — Recovery tower controls

frigerated reflux and hot reboiler vapors. This tower, which usually contains from 24 to 30 trays, is in no way different from an ordinary fractionator, nor does it operate differently. Its controls (Fig. 2) are identical to those of a fractionating de-ethanizer (discussed in a previous article), constant heat input being applied at the reboiler by means of a steam flow controller and all condensible material being returned as reflux by means of a liquid level controller at the reflux accumulator. The recovery tower makes the same cut as does a fractionating de-ethanizer and its bottoms contain nothing but plant products. All methane and virtually all the ethane originally present in the incoming wet gas are discharged from the tower as overhead residue gas. Thus the tower and its refrigeration system perform the same service as do the entire absorption and distillation areas plus the de-ethanizer in an oil absorption plant.

Recovery tower bottoms are discharged to a raw gasoline "surge" or "make" tank, and thence to the product fractionators to be separated into propane, butane, and natural gasoline. A word about the surge tank: ordinarily the recovery tower runs at high pressure, from 200 to 500 psig. Discharging the hot tower bottoms directly to the surge tank would, therefore, necessitate a large, insulated, high pressure vessel — a very costly item. Consequently, it is usual to cool this stream as much as practicable and operate the surge tank at the resultant lowered vapor pressure of the cooled stream. This stream must then be pumped to the depropanizer. As is indicated in the flow diagram (Fig. 1), most of the heat of cooling may be conserved by means of an appropriate system of heat exchangers. The arrangement of exchangers shown in the diagram is by no means the only possible one, nor even necessarily the most economical one in the majority of cases. Rather, it serves to show that some type of exchanger arrangement can always be worked out in order to provide economical operation.

A gas exchanger is shown transferring heat from the warm wet gas feed to the cold residue; this unit conserves a substantial amount of refrigeration otherwise lost because of the low temperature of the departing residue gas. The wet gas chiller shown is not an absolutely essential item, but makes possible the application of a portion of the refrigeration at a higher temperature level than that of the reflux condenser: the liquid condensed in the chiller at, say, 50° would otherwise have to be condensed by contact with internal reflux produced by the reflux condenser at, perhaps, 0°. The consequent saving in refrigeration horsepower is substantial. In setting up the tower feed conditions it seems desirable to provide for a condensed liquid at that point approximately equal in mols to the mols of bottom product. Much more condensation than this at the feed point would result in the re-evaporation within the column of a large amount of light ends with a consequent increase in utilities. Occasionally the situation may arise wherein chilling of the feed may be performed entirely by exchange with the residue. In such cases the chiller may be omitted, but there is a loss in operating flexibility by so doing.

Ordinarily propane is employed as refrigerant; it is conveniently available as a plant product and its vapor pressure characteristics are satisfactory for the entire range of temperatures ordinarily encountered in recovery tower condensers. Having the chiller and reflux condenser operate at different temperatures complicates the refrigeration system somewhat, but since two-stage compression is usually desirable, the chiller can be refrigerated by the upper stage only. Fig. 3 shows such a refrigeration system. Except for the two-stage feature this system is no different from the one described in a previous article (refrigerated oil absorption) and will not be discussed further.

Although it is not shown in Fig. 1, some sort of dehydration plant must process the incoming wet gas before it is subjected to the low temperature conditions prevailing within the recovery tower. If water is not removed, serious hydrate formation may occur and a fouling of tower trays and heat exchange equipment may result. Several types of dehydration processes are available using activated alumina, silica gel, diethylene glycol, and other desiccants. It is not within the scope of this article to conduct a detailed examination of these various processes. Suffice to say that the dehydration system is simple to operate and will constitute

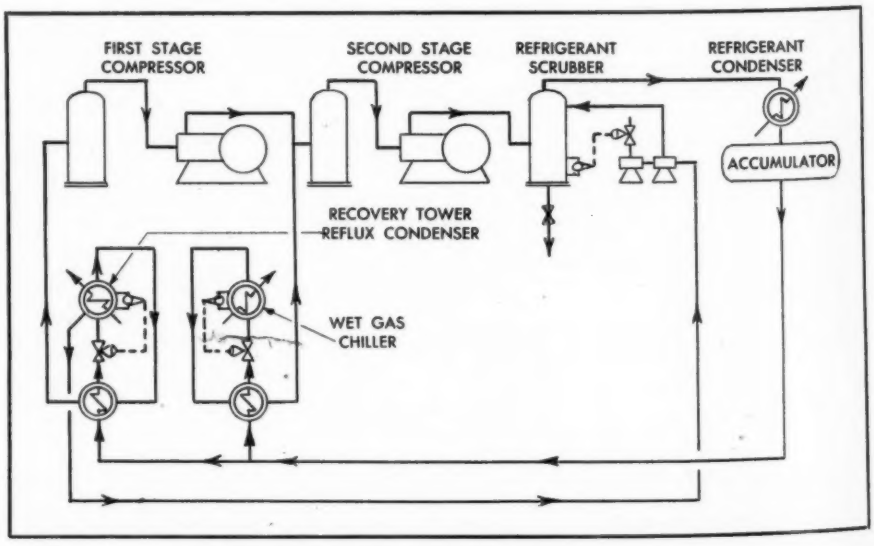


Fig. 3—Recovery tower refrigeration system

but a small fraction of the total plant cost—probably not more than 1 or 1½%. In cost comparisons between gas fractionation and other processes it need hardly be considered as a significant factor. Wherever residue gas marketing considerations require dry gas, a dehydration system must, of course, be installed regardless of the type of gasoline recovery process used.

Comparison of Cost

It might appear at first glance that because of its simplicity the gas fractionation plant would almost always be less costly to build and operate than an equivalent oil absorption plant—but this is true only in a minority of cases at present. The savings effected by eliminating the reabsorber, oil exchangers, absorption oil still, condensers, and de-ethanizer are likely to be nullified by the high cost of the refrigeration plant. The successful development of inexpensive compressors, "package" units, etc. will undoubtedly affect this situation and should enlarge the applicability of gas operation.

With regard to plant operating efficiency, the compressor engine is the limiting factor since most of the fuel burned in the plant is engine fuel. The thermal efficiency of an oil absorption process is very low because of the repeated condensation and reevaporation of products that takes place: the production is condensed in an absorber, partially evaporated and recondensed in a re-absorber, evaporated in a still and recondensed in the fractionators. Furthermore, a large body of absorption oil must be heated and cooled for no other purpose than to remove the raw gasoline and LPG, this duty constituting the bulk of the boiler load. Within the gas fractionation process proper most of these inefficiencies are circumvented, but so low is the thermal efficiency of the compressor engines that the overall fuel consumption of a gas fractionation plant is likely to be comparable to that of an equivalent oil absorption plant.

Then, when is the gas fractionation plant to be preferred? Two main factors must be studied to determine the relative costs of gas fractionation and oil absorption; these are (a) over all propane recovery and (b) wet gas composition—particularly with regard to methane and ethane.

The most significant criteria for comparing the two processes are refrigeration horsepower and absorption oil circulation. The total cost of a plant will not, of course, vary directly as either of these quantities, but the cost of that part of the plant which recovers the valuable constituents and presents them to the fractionators for further processing *is* approximately proportional to the two criteria, so they will be used for cost comparison purposes.

Before proceeding to a relationship between propane extraction and refrigeration horsepower, consider the curves shown in Fig. 4. These are calculated curves based on the same wet gas composition as the sample calculation to be discussed in the next article of this series. 500 psig recovery tower operation is assumed. Curve A relates over-all plant propane extraction (recovery tower extraction) to the recovery tower reflux temperature. This curve has been computed on the assumption that no butanes or heavier are allowed overhead (100% butane recovery), a condition which will be very nearly true at propane recoveries in excess of 60%.

Curve B shows the number of theoretical plates required to perform the fractionation at infinite reflux as calculated by the Fenske equation[1] applied over the entire tower; the same relative volatility of ethane to propane was used for all calculations. This is a rather approximate use of the Fenske equation but the curve serves to show that the number of trays required at infinite reflux is very low—even at 99% propane extraction! Recovery towers normally contain at least 20 *theoretical* trays so it may be assumed that such towers operate very nearly at "minimum" reflux, i.e., act as if they had an infinite number of trays. Accordingly, curve C relates reflux temperature to minimum reflux ratio (mols reflux per mol of overhead residue gas). This curve has been computed by means of Underwood's equations[2] using the same relative volatilities and feed conditions throughout. Constant molal latent heat through the tower is also assumed. All this results in a number of approximations which leave in doubt the accuracy of the calculated reflux rates. The curve properly indicates a trend, however, which fact justifies its use.

The reflux curve C has been converted to refrigeration horsepower and correlated with curve A to give curve D of Fig. 5. This curve relates percent propane extraction with a refrigeration horsepower "criterion" which is roughly proportional to horsepower required. (The horsepower criterion is the product of minimum reflux ratio and brake horsepower per ton of refrigeration, with refrigerant evaporating 10° below reflux temperature and condensing at 100°. Thus its *absolute* value has no significance.)

Fig. 5 also includes a correlation between propane extraction and an absorption oil "criterion". This curve is merely the usual absorption factor curve for 12 plates based on Kremser's equations[3] but corrected on the assumption that 20% of the pro-

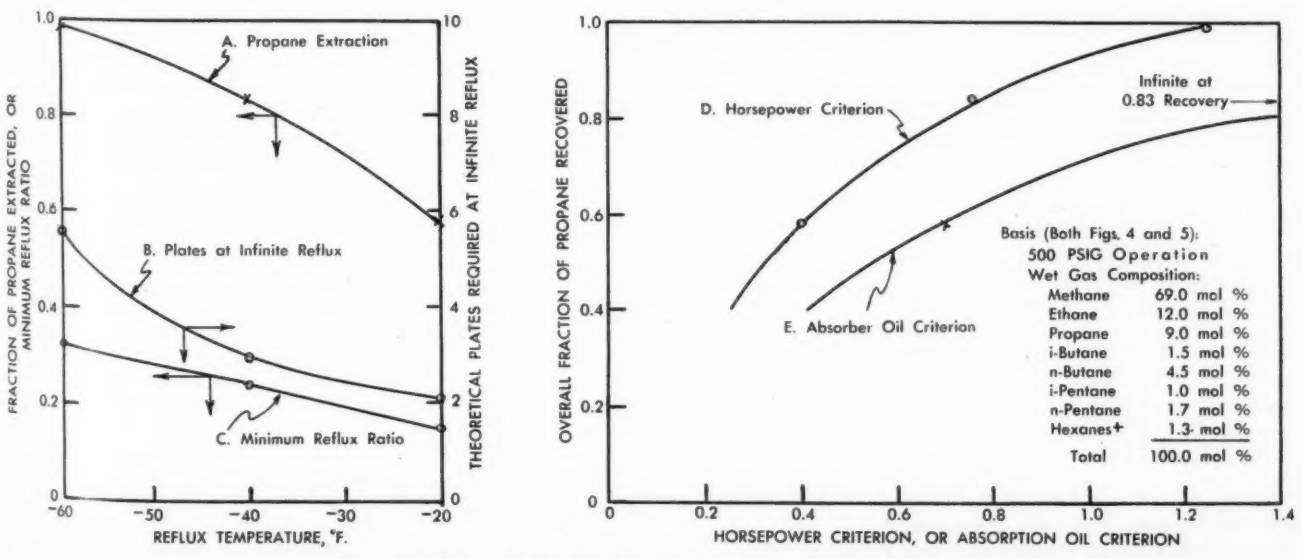

A. Propane Extraction
B. Plates at Infinite Reflux
C. Minimum Reflux Ratio
FRACTION OF PROPANE EXTRACTED, OR MINIMUM REFLUX RATIO
THEORETICAL PLATES REQUIRED AT INFINITE REFLUX
REFLUX TEMPERATURE, °F.
D. Horsepower Criterion
Infinite at 0.83 Recovery
E. Absorber Oil Criterion
OVERALL FRACTION OF PROPANE RECOVERED
HORSEPOWER CRITERION, OR ABSORPTION OIL CRITERION
Basis (Both Figs. 4 and 5):
500 PSIG Operation
Wet Gas Composition:
Methane 69.0 mol %
Ethane 12.0 mol %
Propane 9.0 mol %
i-Butane 1.5 mol %
n-Butane 4.5 mol %
i-Pentane 1.0 mol %
n-Pentane 1.7 mol %
Hexanes+ 1.3 mol %
Total 100.0 mol %

Fig. 4 (left) and Fig. 5—Recovery tower relationships

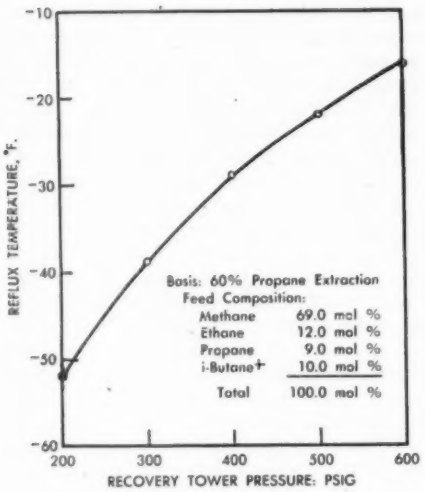


Fig. 6—Effect of recovery tower pressure on reflux temperature

pane retained in an absorber must be lost later in the process. This is an arbitrary assumption, but is fairly accurate for well designed plants within the 40% to 70% propane recovery region. The absorption oil criterion is roughly proportional to absorption oil circulation and therefore gives an indication of plant cost.

Although the absolute values of points on the two curves have no meaning, their comparative curvature is significant. Note that they undergo a continual and increasingly rapid divergence in the *high extraction region.* Consequently, it is in this region that the gas fractionator is most useful. In fact, for a gas of the composition used here, an extraction rate of more than 80 or 85% by conventional oil absorption is virtually out of the question, whereas the gas fractionation process has no difficulty in performing such a service. (The above remarks do not take into account certain newly devised processes using absorber-strippers with multiple absorption oil streams, etc.)

The effect of wet gas composition on refrigeration horsepower may be readily appreciated by referring to Table 1. Evidently wet gas composition radically affects reflux temperature and, as a result, the required brake horsepower per ton of refrigeration. Since the reflux ratio for any given separation is only moderately affected by gas composition, the horsepower per ton figure gives a general indication of the total horsepower that will be required. Therefore, it is apparent that gas fractionation will be most effective when applied to "rich" gases. This is true also of absorption processes but to a much smaller extent.

Because of this composition effect, most applications of gas fractionation to natural gas processing have occurred in fields where extremely rich gases were available. In East Texas, for example, gases approximating the composition of gas (a) in Table 1 are not unusual and a number of fractionation plants have been constructed in this area. At the time some of these plants were designed, propane recovery was of no importance and satisfactory recoveries could sometimes be obtained with water cooling alone. But, as the importance of propane and butane recovery increased, these plants have had to refrigerate their recovery towers or enlarge existing refrigeration plants. One of the merits of the gas fractionation plant is that such re-adjustments can be accomplished with a minimum of redesign and plant shutdown. Radical increases in absorption plant extraction rates usually require very substantial process changes, as has been pointed out earlier in this series.

It has been explained that the gas fractionation system becomes less costly than oil absorption only when applied to situations involving rich gases and/or high extraction rates. But at what point does this occur? This question can only be answered in a very general way. For gas (a) of Table 1, gas fractionation should be economical throughout the entire range of extraction rates ordinarily encountered. For gas (c), fractionation would probably be attractive only for the very highest extraction rates if at all—perhaps 80% propane or better.

With regard to gas (b), two years ago the authors participated in a thorough comparative cost estimate for 60% propane recovery from a gas approximately of this composition. It was determined that, under these conditions, equivalent absorption and fractionation plants would have about the same initial cost and fuel consumption: the systems were a "standoff"! If these facts are kept in mind it should not be difficult to tell, in most cases, whether or not gas fractionation may be applicable. However, if an element of doubt remains, complete comparative estimates should be conducted. Such comparisons are somewhat simplified by the fact that much of the equipment will be identical for the two types of plant.

TABLE 1—Effect of Gas Composition on Refrigeration

Basis: 60% Propane Extraction; 500 psig. Operation; 10° Temperature Approach in Condenser

	Component	Mol % in Wet Gas	Reflux Temp., °F.	BHP/Ton of Refrig.
(a)	Methane	60		
	Ethane	15		
	Propane	12	—7°	2.4
	i-Butane+	13		
		100		
(b)	Methane	69		
	Ethane	12		
	Propane	9	—22°	2.7
	i-Butane+	10		
		100		
(c)	Methane	80		
	Ethane	8		
	Propane	5	—47°	3.4
	i-Butane+	7		
		100		

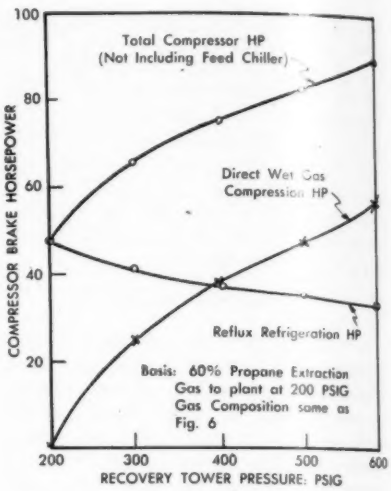


Fig. 7 — Distribution of compressor brake horsepower in a gas fractionation plant

Effect of Operating Pressure

The operating range for the recovery tower of a gas fractionation process is, roughly speaking, between 200 and 500 psig. Below 200 psig, reflux temperatures are likely to be extremely low. Above 500 psig, recovery tower operation is likely to become unstable due to the fact that the critical pressure of the bottom product will not be much greater than 550 to 600 psig. (It is a common observation in the case of fractionating de-ethanizers that operation above 500 psig is extremely difficult due to the production of abnormally large quantities of reboiler vapors. Fractionating de-ethanizers make substantially the same separation as do recovery towers and produce the same bottom product.)

These pressure considerations limit the use of gas fractionation to certain pretty well defined cases. In the first place, it is not applicable to very high pressure cycling plants. For example, in a cycling plant receiving wet gas at 4000 psig. and returning residue at 5000 psig, it would be necessary to drop the wet gas to perhaps 500 psig, for processing and recompress the residue from 500 to 5000 psig. In an absorption plant, pressure of the incoming wet gas likewise would have to be dropped because of retrograde effect, but not nearly so far. The equivalent absorption plant would operate at perhaps 1800 or 2000 psig. and consequently the injection compressor horsepower would be much less than would be

required in the gas fractionation type of plant.

The ideal application of gas fractionation is in the processing low pressure separator gas which must be delivered to pipe line or formation at high pressure. Such a gas is likely to be quite "rich" and the desirable high pressure is available without being chargeable to the process. If the delivery pressure is greater than 500 psig., the recovery tower may be operated at the discharge of an intermediate compression stage. High pressure separator gases may also be processed by fractionation, but since they are likely to be quite "lean", lower reflux temperatures and a larger refrigeration plant may be required for a given production.

Fig. 6 shows the way in which recovery tower pressure affects reflux temperature in a typical case. Note that the reflux temperature begins to drop off rapidly at lower pressures, requiring a large refrigeration plant for low pressure operation. This fact raises the question of whether or not it might be advisable to compress incoming wet gas prior to processing regardless of whether or not a high delivery pressure were required. Such operation would, in effect, replace some of the refrigeration horsepower with horsepower applied directly to wet gas. The effect of varying tower pressure on this distribution of horsepower is shown in Fig. 7. In the computation of this chart, horsepower required for chilling the feed has been ignored as being relatively small compared with that required to condense reflux, and it has been assumed that the reflux refrigeration duty remains unchanged over considerable variations in operating pressure. The latter assumption is only approximately true, this duty must increase somewhat at higher pressures because of decreased relative volatilities of key components.

Fig. 7 indicates that for a gas entering a plant at 200 psig., it is undesirable to process the gas at any higher pressure unless marketing considerations require higher pressure residue gas. This is true because at higher pressures direct compression horsepower increases more rapidly than refrigeration horsepower decreases. Whether or not this would be true of a gas entering at, say, 50 psig. is difficult to say. Recovery tower operation at such a low pressure would require an extremely low reflux temperature for which the available data is sketchy. It is probable, however, that at some sufficiently low incoming gas pressure it would be desirable to raise the operating pressure to avoid an otherwise extremely low refrigeration temperature.

For plants that are compressing to a pipeline, high pressure operation is, of course, very desirable. However, it requires some study to determine whether the tower should operate at the plant discharge pressure or some intermediate pressure. Operating at the discharge pressure has the advantage of minimizing refrigeration horsepower and requires less of a dewpoint depression on the part of the dehydration system. However, operating at some intermediate pressure not only requires less heavy equipment, but also means that part of the direct compression horsepower is applied to residue gas rather than to incoming wet gas.

High Pressure Reflux Condensation

The situation occasionally arises wherein it seems desirable to operate the reflux condenser and accumulator at a higher pressure than the tower. This might occur, for example, if one wished to convert a stabilizer to recovery tower service; the stabilizer might be good for only 200 psig. operation whereas 300 psig. tower operation might be more desirable. This problem may be solved by using the arrangement shown in Fig. 8. Direct compression is applied to the tower overhead prior to its entry into the reflux condenser. The condenser outlet conditions are exactly as they would be if the entire system were operating at the higher pressure. The reflux pump is, of course, eliminated.

The only important disadvantage in this arrangement is that the refrigerated reflux condenser must extract not only the heat required to evaporate internal reflux in the tower, but also the energy imparted to the overhead vapors by the compressor. This tends to cancel the savings in refrigeration horsepower due to a higher reflux temperature. Furthermore, since the overhead vapor compressor must compress reflux as well as residue gas, it is likely that more direct compression will be required with this arrangement than would be required if the tower were operating at the higher pressure.

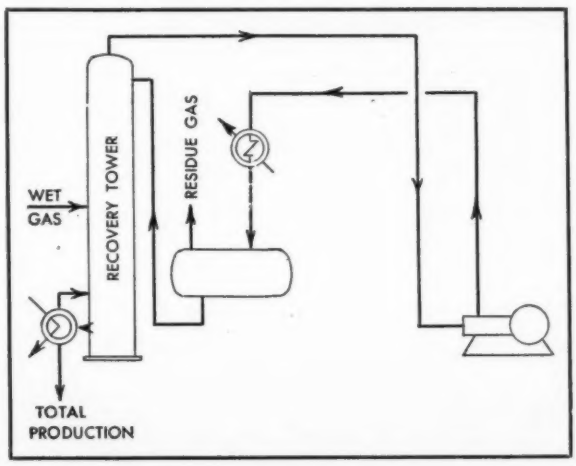


Fig. 8—*High pressure reflux condensation*

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Reprints of Design Series Available

Reprints of the complete series of eight articles on "Short Cut Process Design to Increase Propane Recovery in Gasoline Plants," by Alan S. Glendening and Charles F. Sanderson will be available following publication of the eighth and concluding article in the September issue of PETROLEUM PROCESSING. The reprint will be publication size, bound in a heavy paper cover, and will include the following:

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Hydrogen Blistering of Steel A Source of Damage to Vessels

By M. H. BARTZ and C. E. RAWLINS, Phillips Petroleum Co.

The cause of blistering of vessel walls and other refinery equipment is found to be the attack of atomic hydrogen released by the acid corrosion of the steel. This same condition may lead to embrittlement of the steel, particularly at high temperatures. Use of corrosion resistant linings to keep the corrodent away from the carbon steel shells of vessels has been adopted as one means of controlling hydrogen blistering. Few actual failures of blistered equipment have been reported. By locating blisters before numerous or large cracks develop serious failures from this cause can be prevented.

The following article was originally presented by the authors under the title "Hydrogen Blistering Reported by Several Oil Companies" before the Session on Corrosion at the 14th Mid-Year Meeting of the API Division of Refining, Houston, April 4-7, 1949. Appendix A as published here has been condensed from the original paper.

DURING the past few years a number of articles[1-8] have described petroleum processing equipment that blistered and embrittled from hydrogen released as the equipment corroded. Affected units have been found in a variety of installations, handling such diverse products as sour crudes, sour crude fractions, sour natural gases and gasolines, phenol, sulfuric acid, and mixtures of hydrocarbons and hydrofluoric acid.

At its Nov. 6, 1948, meeting, the American Petroleum Institute Subcommittee on Corrosion of Refinery Equipment decided to make an effort to assess the seriousness of the damage from hydrogen blistering and to correlate the experiences various oil companies have had with steels blistering from hydrogen. All members of this subcommittee were asked to submit case histories of any hydrogen blistering found in their company's equipment.

Of 13 oil companies contributing information, ten reported blistered steels in their equipment, two reported failures from hydrogen embrittlement and two reported that blistering had not been a problem in their operations. Table 1 summarizes the conditions reported as regards pressure vessels. Other than in vessels, blisters were reported in storage tanks, piping and flanges.

Causes of Blistering

There is general agreement that blisters develop only in steels that are corroding and releasing nascent hydrogen from the corrodent. This newly formed hydrogen may combine to form molecular hydrogen and harmlessly dissolve in the solution or bubble off. Some of the atomic hydrogen, however, will penetrate and diffuse through the steel that is being corroded. If this diffusing atomic hydrogen encounters a break or discontinuity within the solid metal, it will collect on this internal surface and one atom will combine with another to form molecular hydrogen. Once in the molecular form, the hydrogen is incapable of diffusing further. As additional atomic hydrogen diffuses into the cavity and forms molecular hydrogen, the pressure of the entrapped gas increases and may become great enough to deform and rupture the steel.

Most of the blisters observed in petroleum processing equipment have been traced to massive discontinuities within the steel. Laminations, large inclusions, stringers of small inclusions, phosphorus segregations, and other highly segregated zones have been found to be nucleating points for blisters. It seems probable that even within individual grains smaller "disjunctions" or "rifts" too small to be seen with the microscope may also tear open to grow into blisters or cracks.

Blisters have been tapped and the entrapped gas found to analyze 99.5% hydrogen, with less than 0.5% water vapor, carbon dioxide, air and carbon monoxide combined. Pressures of the hydrogen up to 2700 psi have been measured in some blisters[8]. Theoretically, much higher pressures could develop.

Acid corrosion that releases atomic hydrogen appears to be a requisite for blister formation. Hydrogen sulfide is present in abundance in many refining processes and is one of the corrodents most responsible for blister formation. Perhaps hydrogen sulfide serves a dual role in blister for-

TABLE 1—Oil Companies Reporting Blistering, and Conditions Encountered with Pressure Vessels

Ashland Oil & Refining Co.[20]	Equipment failure from hydrogen embrittlement
Atlantic Refining Co.[10]	6 blistered vessels
Cities Service Refining Corp.[9]	8 blistered vessels
Continental Oil Co.[12]	3 blistered vessels
General Petroleum Co.[11]	4 blistered vessels
Gulf Oil Corp.[13]	Undisclosed number of blistered vessels
Magnolia Petroleum Co.[18]	Hydrogen blisters not encountered
Phillips Petroleum Co.[8]	Over 50 blistered pressure vessels Failures from hydrogen embrittlement
Pure Oil Co.[19]	Hydrogen blisters not encountered
Shell Oil Co.[14]	Undisclosed number of blistered vessels
Standard Oil Co. (Indiana)[15]	Undisclosed number of blistered vessels
Standard Oil Co. of Ohio[17]	Undisclosed number of blistered vessels
Sun Oil Co.[16]	Undisclosed number of blistered vessels

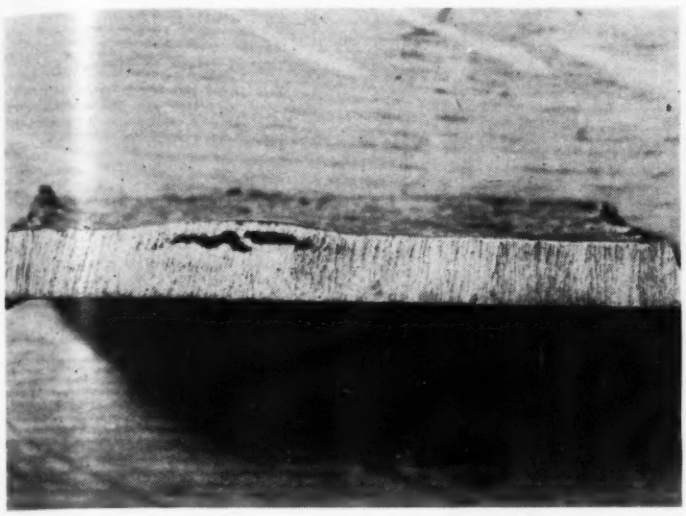

Fig. 1—Longitudinal section of condenser shell with blister at inner wall (Shell Oil Co. photograph)

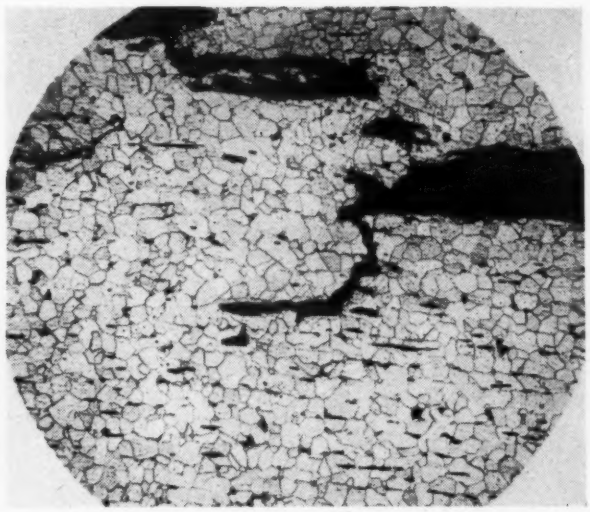

Fig. 2—Crack at edge of a blister connecting discontinuous inclusions (Shell Oil Co. photograph)

mation. First, in aqueous solution it behaves as an acid solution and during corrosive attack will release atomic hydrogen. Second, it may be a powerful "promoter" that increases the rate of hydrogen penetration into the steel[8]. Cyanides have also been reported present in some streams that blistered equipment and are suspected as being another "promoter" of hydrogen absorption[9].

Hydrofluoric acid, sulfuric acid, and phenol also are reported to cause blistering in petroleum processing equipment.

Hydrogen Embrittlement of Steel

The same conditions that cause steel to blister may cause it to become brittle. Thus far severe embrittlement has been limited to higher strength steels. Hydrogen embrittlement of the low alloy carbon steels used for pressure vessels, piping, and structural purposes by the oil industry, has not occurred, or at least never has been found to be a serious problem.

Hydrogen embrittlement has been explained on the basis of hydrogen collecting in extremely numerous and small "disjunctions" within the steel. As hydrogen collects in these disjunctions and the resulting deformation increases, the metal becomes highly stressed multi-axially. Metal stressed in this manner cannot flow and a high superimposed stress will cause brittle failure.

High and Low Temperature Attack

The method of hydrogen attack of steels at elevated temperatures is distinctly different from the way it attacks steels at low temperatures. At high temperatures the diffusing hydrogen will react with carbon and other non-metallic impurities. Methane and other insoluble gaseous products will form and collect at grain boundaries at high pressures to embrittle and otherwise impair the mechanical properties of the metal. Reactions of this sort do not occur, and steels are not decarburized, at low temperatures.

Stabilizing the carbon by adding chromium, titanium, vanadium, etc. is effective in preventing high temperature hydrogen attack. Other than by reducing the rate at which the metal corrodes, these alloys are of little value in reducing the harmful effects of hydrogen at low temperatures.

Early Experiences

About ten years ago, Sun Oil Co.[16] found blisters in gasoline-water separators and in other refinery equipment. All the details of operating conditions of these vessels are not now known. However, the liquids handled were more or less on the acid side and hydrogen ions were present in considerable quantity.

In 1939 Shell Oil Co. conducted a detailed metallurgical examination of a blistered condenser shell[14]. The vessel operated as a butane condenser, working at 125 psi. with water inside the tubes and vapors through the shell. The operating temperature was under 300° F. The condenser shell was made of 16-in. diameter seamless carbon steel pipe.

The wall thickness varied from 0.335 to 0.353 in. This difference in wall thickness was due to different corrosion rates around the shell.

TABLE 2—Mechanical Properties of Inside and Outside Layers of Condenser Shell Wall

Property	Inner Wall	Outer Wall
Yield Point, psi.	30,400	32,000
Tensile Strength, psi.	44,500	50,600
% Elongation in 2 in. ..	21	41
% Reduction of area	28	62
Hardness Rockwell B	52	58
Type of Fracture	Laminated	Rough
Size of Test bar, in. diam.	0.1785	0.1785

There were a large number of blisters on the inside surface of the shell wall. The blisters varied in diameter up to 1⅛ in. and protruded up to $\frac{1}{16}$ in. above the steel surface. None of the blisters was over $\frac{1}{16}$ in. below the surface of the shell. A cross-section of one of the blisters is shown in Fig. 1. The appearance of the edge of one of the blisters that developed into a crack connecting interrupted lines of inclusions is shown in Fig. 2.

The mechanical properties of both the inside and outside layers of the wall of the condenser shell were determined to be as given in Table 2.

On further examination, it was felt there was intergranular attack of the inside wall, with evidence that the manganese sulfide inclusions near the inside surface had reacted with the migrating hydrogen.

Etching a section of the plate in hot hydrochloric acid showed the steel near the inner wall to be honeycombed with small cracks. The steel contained more slag inclusions than are normally found in an average quality steel.

The cause of this blistering was attributed to the liberation of atomic hydrogen during the corrosion of the shell. The atomic hydrogen was visualized as entering into the steel and reacting with the sulfides in the inclusions to form hydrogen sulfide. The pressure of this gas was sufficient to break the steel internally and cause blisters on the inner wall.

A cleaner steel was suggested to eliminate reappearance of the larger blisters. Limiting phosphorus and sulfur to 0.03% maximum was felt desirable.

Phillips Petroleum Co.[8], late in 1940, had a failure in a sour natural gasoline storage tank. The tank contained gas under 30 psi. pressure at the time of failure. Rupture took

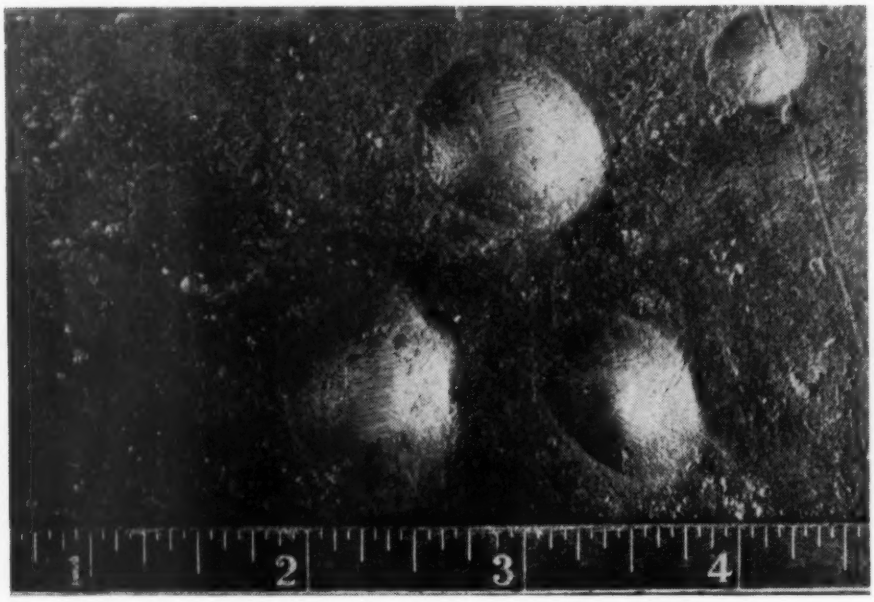

Fig. 3—Appearance of blisters after removing paint from outside surface of failed vessel (Phillips Petroleum Co. photograph)

place along the knuckle of one head. Many blisters were present and visible on both the outside and inside walls. Some of the blisters found on the outside of one of the plates are shown in Fig. 3. Most of the blisters were small, although some were 3 to 4 in. in diameter and elongated with the major axis in the rolling direction of the plate.

Many of the blisters had cracked from their edges toward the surface of the plate. A series of such disconnected cracks weakened the most highly stressed portion of the vessel and provided a path along which the fracture progressed.

Case histories of hydrogen blistering and of hydrogen embrittlement, as reported in the study by the API Subcommittee on Corrosion of Refinery Equipment, are given in the Appendix.

Control of Hydrogen Damage

The most effective way to control hydrogen blistering would be to control corrosion. Various methods have been suggested to do this. Gunite linings have been used to keep the corrodent away from the carbon steel shells of vessels that have blistered[9]. Vessels have been lined with alloys that resist the corrosive attack of the streams being processed. Stainless steel and lead linings have been suggested to accomplish this.

Removing the corrodent would be a most effective method of corrosion control. Usually, this would require neutralizing the acid or removing the hydrogen sulfide before it had an opportunity to contact much equipment.

By improving the homogeneity of the steel, the number of massive laminations and large inclusions that nucleate blisters should be reduced. Firebox quality killed steels that meet specifications similar to ASTM A-201 or A-212 should offer an improvement over the semi-killed or rimmed steels that may be furnished under ASTM Standards A285 (A-70—A-89), A-283 (A-10—A-78), or A-30.

The microstructure of steel has been found to have some bearing on the susceptibility of steels toward blistering. Plates that have been finished at the mill at a somewhat higher than average temperature, as indicated by retention of a semi-Widmanstatten structure, have been practically immune from blistering. The explanation of this could possibly be found in the fact that plates that are rolled at somewhat higher than normal temperatures have more of the voids and discontinuities thoroughly welded together than is obtained under normal conditions of rolling[16].

On some occasions it has been necessary to remove blistered vessels from service. At other times the permissible working pressure has been reduced or a portion of a blistered vessel has been replaced. Where blistering has been minor, vessels have been kept in service under closer surveillance.

Embrittlement may be combatted by substituting more corrosion resistant materials. The use of stainless steels, monel, aluminum coatings, and other alloys highly resistant to H_2S has been very effective in reducing breakage of hardened valve parts, bourdon tubes, springs and bolts in equipment handling either very sour hydrocarbons or mixtures of hydrocarbons and hydrofluoric acid.

As shown in this summary of various oil companies' experiences, hydrogen blistering and embrittlement have occurred in a variety of installations processing different kinds of crudes by different processes. Although quite a number of vessels have blistered, few actual failures of blistered equipment have been reported. This may be due to careful surveillance, constant repairing and derating of vessels in installations where the causes and possible effects of blistering are recognized. On the other hand, failures from hydrogen blistering and embrittlement may have been falsely attributed to factors having no part in causing the failure, or may remain unexplained in those installations where the effects of hydrogen are not appreciated.

The quality of steel is a factor. Some steels blister and others do not. It is apparent that much of the steel furnished for use in pressure vessels contains many and large laminations. If it were not for blistering, these laminations generally would not be serious. Where blistering and cracks form, these laminations become extremely objectionable. Cracks 18 in. long half way through 1-in. plate in pressure vessels cannot be discounted as being of theoretical interest only. A real hazard exists and this should be recognized by the steel industry, as well as the oil industry.

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Appendix—Case Histories of Hydrogen Blistering and Hydrogen Embrittlement

Condensed from Data in Original Report

HYDROGEN BLISTERING

Atlantic Refining Co.

Poly Feed Accumulator at Poly Recovery Plant: 130 small blisters were discovered on the inside of the vessel in 1948. One raised surface about 4 in. in diameter was observed. This vessel was 6 ft. I.D. by 14 ft. 2 in., horizontal, fabricated in 1937 of 1¼-in. ASTM Spec. A-70 Firebox quality steel. Designed for 350 psi. max. operating pressure, 150° F. max. operating temperature and a ⅛-in. corrosion allowance. It was fusion welded, x-rayed and stress relieved.

Until April, 1945, the vessel handled feed containing 10-50 grains of H_2S per 100 cu. ft. From this time on except for standby period, vessel handled hydrocarbons with 3000-5000 grains of H_2S per 100 cu. ft.

Examination of a large blister $\frac{1}{16}$ to ⅜ in. below the inside surface indicated it was part of a larger continuous lamination extending 48 in. circumferentially and 24 in. longitudinally, the lamination varying from $\frac{1}{16}$ to ⅞ in. below the internal surface of the plate.

A $\frac{1}{16}$-in. carbon steel liner had been installed in this vessel in April, 1948, covering the entire bottom section for 36 in. on both sides of the center line. The liner was required because of severe pitting corrosion of the sour water type. The liner buckled as shown in Fig. 4.

The two sections of the liner with the largest bulges were drilled and samples of the gas under the buckles were analyzed. The close agreement of the entrapped gas analysis with the stream analysis suggests the stream gases may have leaked under the liner.

The chemical analysis of the steel was carbon 0.22%, manganese 0.12%, phosphorus 0.45% and sulfur 0.024%. This analysis meets the specification for ASTM A-70 Firebox steel.

Emission spectra analysis of the material on the internal surface of the large blister showed it to consist of 30.00% silicon, 0.50% aluminum, 0.50% barium, 0.01% calcium, 0.50% lead and 0.05% magnesium. Manganese, phosphorus, sulfur and carbon were not determined.

Vis-Breaker Gas Separator: Over 100 blisters, in size from ¼ in. to 1½ in. diam. were found on the exterior surface. The vessel was 6 ft. I.D. and 24 ft. long. Shell and hoods were of ⅜-in. thick ASTM A-70 Firebox steel. Max. working pressure was 25 psi.; max. temperature was 100° F.

The blisters were confined to the bottom half of two rings, the third ring being blister free. The large blisters were drilled and no pressure could be detected in the cavities, which were about ⅛ in. below the surface. No surface cracks could be detected nor any continuation of the laminations past the boundaries of the blisters. No repairs were thought necessary.

Sour Distillate Tanks: 76 small blisters were found on six of eight sheets of the first ring of a sour distillate tank built in 1931, and used in distillate (mostly sour) service at gas holder pressure. Vessel was 40 ft. diam. and 36 ft. high, of riveted globe type roof construction, built of ASTM A-10 Tank steel.

The blisters were half on the inside and half on the outside surfaces of the sheets. They varied in size from ½ in. to 2½ in. diam., and were from $\frac{1}{32}$ to $\frac{3}{32}$ in. below the surface. On drilling, some of the blisters indicated a pressure build-up.

Three small blisters were found on a neighboring sour distillate tank constructed at the same time and in the same manner and used in similar service. No repairs were made on either tank; however, the blisters were marked so that any increase in number or size could be detected in the future.

Acid Blow Case: Five small blisters from 1⅜ to 2⅝ in. diam. were discovered in a vessel handling 83 to 90% sulphuric acid. Since March, 1943, some alkylate has been entrained in the acid.

The vessel was 5 by 8 ft., fabricated in 1939 of ASTM A-70 Firebox steel. Heads were ⅝ in. thick, shell $\frac{9}{16}$ in. thick. Vessel was designed for 150 psi., with a 125 psi. safety valve setting, 100 psi. max. operating pressure, 120° F. max. operating temperature and a ⅛ in. corrosion allowance.

The blisters were located from 2½ to 3½ ft. above the bottom head seam and from 2½ in. to 8 ft. clockwise, from the vertical seam when viewed from the top of the vessel. Three blisters were drilled with no evidence of gas pressure within. No repairs were made.

Cities Service Refining Corp.

In September, 1947, many small blisters were found in one of the condensers (C-15 in Fig. 5) handling the overhead gases from a depropanizer tower. In December, 1947, during a turnaround, very severe blistering and cracking were found in the Splitter Reflux Drum (F-2 in Fig. 5). Samples of blistered steel from this vessel were subjected to a diluted chemical, physical, and metallographic examination.

Chemically, the steel was found to meet the specification of ASTM A-70 steel in containing 0.19% carbon, 0.42% manganese, 0.022% phosphorus, 0.033% silicon, with nickel, chromium, and copper reported as "none". Mechanical properties were determined to be 65,700-72,200 psi. tensile strength, 43,700-44,500 psi. yield strength, 32-36% elongation in 1.4 in., and 54-60% reduction of area. On metallographic examination the steel was noted to contain an excessive amount of non-metallic inclusions. Blisters found in the rings, head and water pot were cracked in the dome of each blister. Shell section was made of ASTM A-7 steel, head of A-70 and the water pot of seamless pipe.

During the same turnaround considerable blistering and cracking of the blisters was noted in five of the nine condensers handling the overhead from the splitter tower. Blisters were also found inside some of the

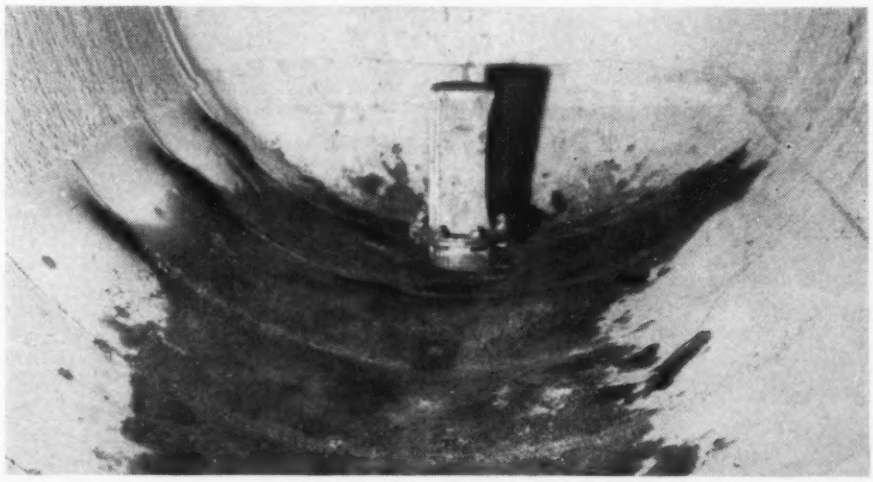

Fig. 4—Buckled liner in poly feed accumulator (Atlantic Refining Co. photograph)

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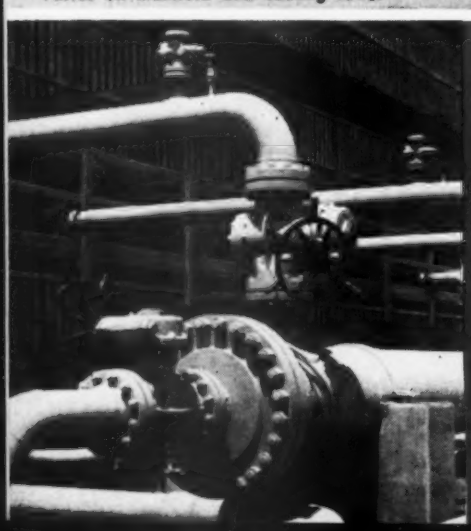
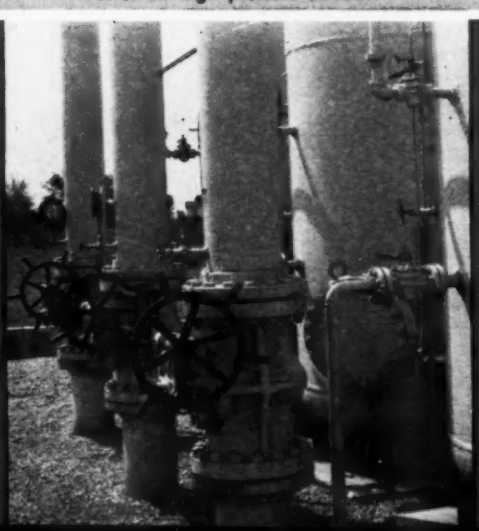
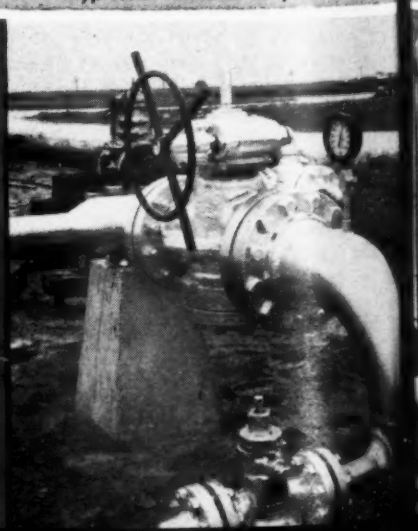


Valves on high pressure scrubber



Hypreseal valves in dehydration plant



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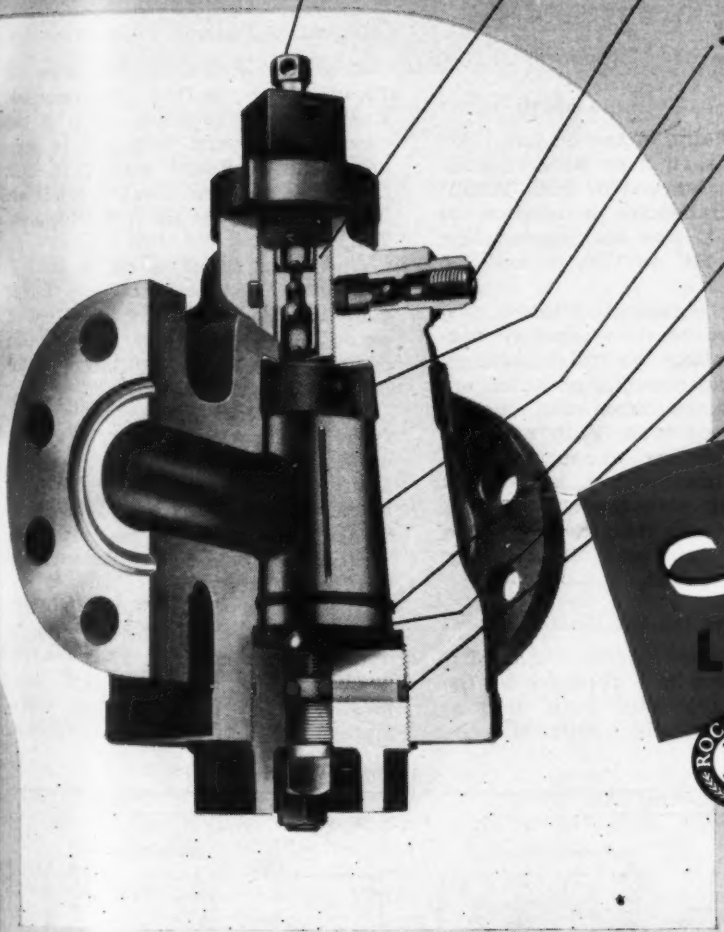
- STEM PACKING CAN BE INJECTED WHILE VALVE IS IN OPERATION
- FLOATING EQUALIZER TRANSMITS TORQUE FROM STEM TO PLUG
- FULL FLOATING PLUG IS BALANCED UNDER HIGH PRESSURES
- LUBRICANT GROOVES IN PLUG CONNECT WITH BODY GROOVES TO FORM POSITIVE SEAL AROUND PORTS
- SINGLE BALL THRUST BEARING APPLIES THRUST AGAINST SPRING TENSION DISC UNDER PLUG
- ANNULAR SEALING GROOVE, FILLED WITH PLASTIC STEM PACKING, SEALS BOTTOM PLUG AND ADJUSTING SCREW



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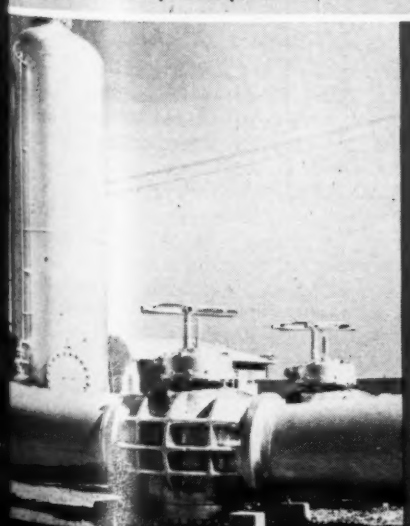
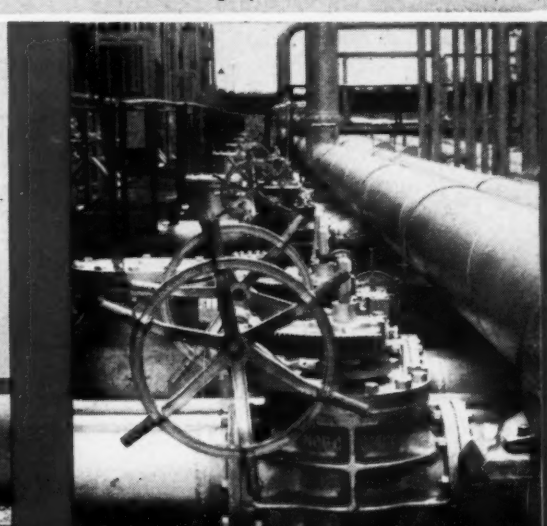
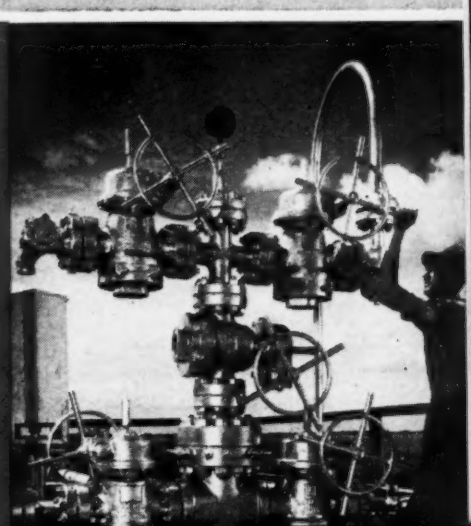


Valves on high pressure manifold header



High pressure Christmas tree valves



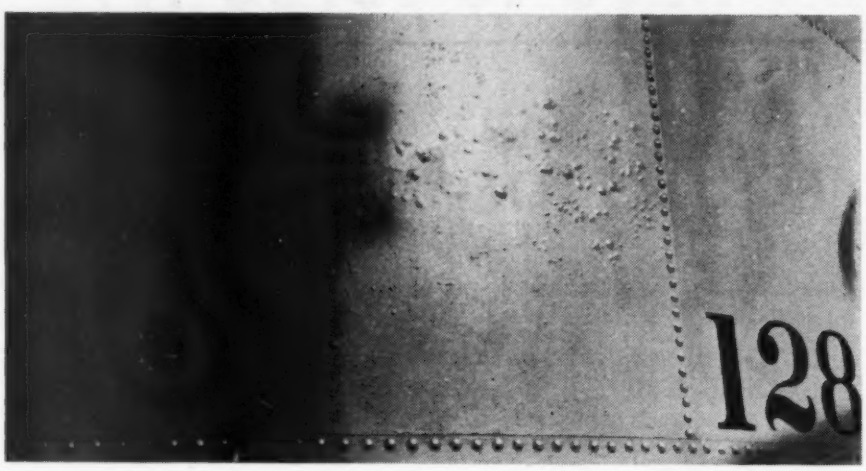


Fig. 6—Hydrogen blisters on the surface of a storage tank (Standard Oil Co. of Indiana photograph)

piping in the discharge of the compressors, shown as J-5 and J-8 in Fig. 5.

In September, 1948, the paint on the cold parts of the system showed considerable blistering. The paint blisters grew to about 1½ in. diam. and were constantly increasing in volume. By mass spectrometer analysis four badly contaminated samples of gas were reported to contain 5.0%, 15.0%, 11.7% and 12.5% hydrogen. Within 24 hours after the unit was shut down, pressure in the blisters had dropped materially and 12 hours later the blisters were almost deflated.

In January, 1949, the depropanizer reflux drum (F-4 in Fig. 5) was found to contain many small internal blisters.

Appreciable corrosion in this system was noted only in the exchangers handling feed from the depropanizer tower and in the splitter reflux drum. Sufficient H_2S is reported to be present to be the corrosive agent. Analysis of a sample of water removed from the depropanizer reflux drum had a pH of 8.0 and contained 1% $(NH_4)_2S$. Since cyanides have been found consistently in these streams, it is suggested[9] that hydrogen sulfide is responsible for the corrosion and the cyanides promote entry of atomic hydrogen into the steel surfaces.

Continental Oil Co.

Blisters located in three pressure vessels, two in HF service and one handling straight-run light naphtha.[12] Numerous blisters ranging up to 6 or 7 in. diam. were found in three or four plates in the center portion of the naphtha surge drum, noticeable on both the inside and outside of the vessel, which was constructed of ASTM A-285 (A-70) plain carbon steel and operated at atmospheric pressure and 100° F.

Inspection in January, 1949, disclosed about 12 hydrogen blisters, 3 to 4 in. diam., in the bottom plate of the inner shell of an HF contactor. The vessel, fabricated from ASTM A-285 steel, handles a mixture of butane, butene and iso-butylene mixed with HF at 175° F. and 125 psi.

In an acid regeneration tower, blisters occurred on two manway nozzle flanges along the inside surfaces. They were not visually observed but were discovered when the flanges were machined to a depth of about ⅛ in. The blisters, measuring ¼ to ½ in., ruptured with a loud report upon contact with the cutting tool. The vessel, constructed of ASTM A-285 steel, contained HF vapor at 375° F. and 100 psi.

Standard Oil Co. (Indiana)

This company reports[15] that hydrogen blisters have appeared on the surface of a storage tank used as a container for the condensed overhead vapors from a pipestill fractionating tower. A sour crude, with a total sulfur content in the range of 1.5% to 2% by weight, and about 0.43 lbs. of salt per 1000 bbls., is charged to the pipestill.

The storage tank constructed in 1945 of ASTM A-70 flange quality steel, was 30 ft. diam. and 18 ft. high (three courses). The blisters, as shown in Fig. 6, appeared in two adjacent plates in the second course. One plate had about 150 blisters ranging from ½ to 2 in. diam., the other plate had about 75 blisters evident. Heavy deposits of FeS were observed on the interior surfaces of the tank.

General Petroleum Corp., Torrance

Gas Absorption Plant—Rich Oil Fractionator Reflux Accumulator: Blisters were found in 1945 in this vessel, which had been put in service in 1943. Vessel was 7 ft. O.D. by 30 ft. tangent length; heads are 2:1 ellipsoidal, ¾ in. min. thickness, 2-in. flange.

Operating range is 80 to 100° F. at between 85 and 105 psi. Liquid content is raw B-B; H_2S content of liquid 1.5% by volume. H_2S content of vent gas off top of accumulator is 10.7% by volume.

Blisters were at a depth of ⅛ in. from the inside surface, 1 to 2 in. in diam. and bulging up to ⅛ in. high. Many were high enough to crack across the top. Largest number were on the lower half of the head. Fig. 7 is a close view of blisters on the head plate.

Chemical analysis of the blistered head plate showed the steel would qualify chemically for either ASTM A-212, A-201 or A-70 steels. Samples analyzed 0.14% carbon, 0.52% manganese, 0.019-0.023% phosphorus,

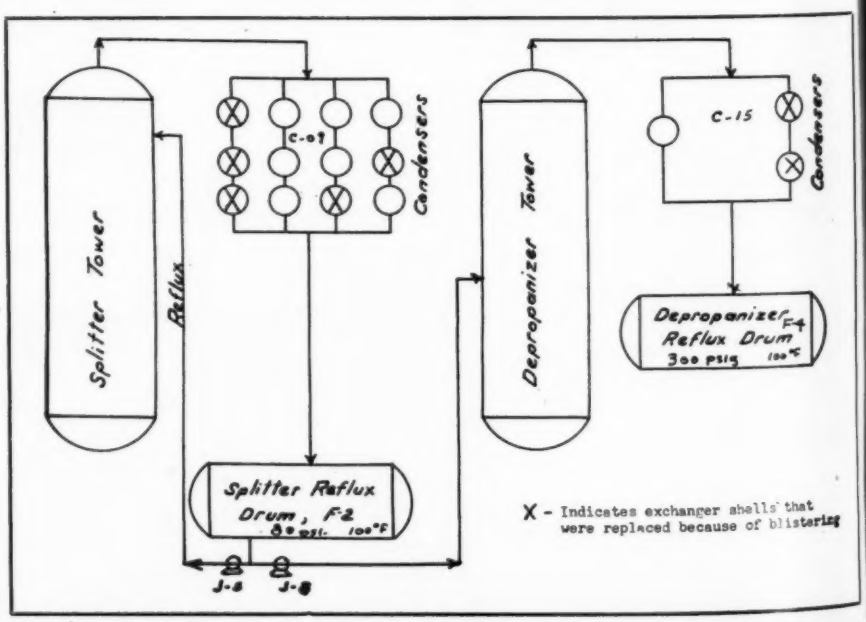


Fig. 5—Diagram of a Cities Service processing unit, showing blistered equipment

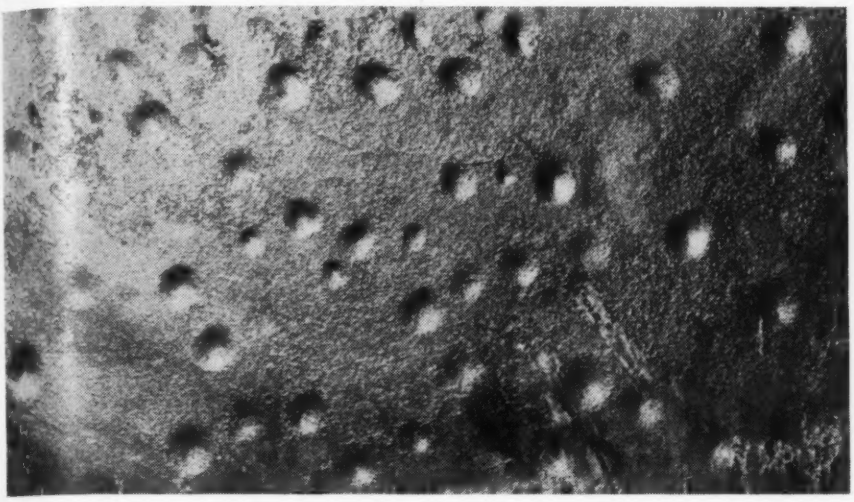


Fig. 7—Blisters in rich oil fractionator reflux accumulator (General Petroleum Corp.)

0.031-0.038% sulfur, 0.24% silicon, and 0.051% aluminum.

After service, the mechanical properties were such that the material would meet neither ASTM A-212, A-201, nor the old A-70 tensile requirements. Properties were: Tensile strength, 49,000 psi.; Yield Strength, 33,000 psi.; Elongation in 2 in. 12%; Reduction of area, 24½%; Hardness, Rockwell B, 60-62.

Fig. 8 shows the fracture that developed in breaking a standard 0.505-in. tensile specimen. While the small laminations visible throughout the fracture may have been present to some extent when the plate was put in service, it is probable that hydrogen opened and enlarged many of these potential laminations.

The damaged accumulator was replaced. Its blistered head was replaced and the vessel was installed in another service.

H. F. Alkylation Unit-Acid Dump and Blowdown Tank: Hydrogen blisters first found in 1948 in vessel put into service early in 1944. Its size was 10 ft. O.D. by 50 ft. tangent length. Shell was 1 in. thick. Heads were 2:1 ellipsoidal, 1 in. min. thickness. Material was ASTM A-70 flange quality steel.

Evacuating, dumping and venting of all equipment in the "Acid Section" is done into this vessel. A small scrubbing column refluxed with iso-butane removes acid from gases escaping to the atmospheric neutralizing tower. Contents would be a mixture of light hydrocarbons (predominantly iso-butane) and varying amounts of HF acid. The acid may exist in different degrees of purity, but will generally be in the neighborhood of 90% with only traces of moisture present. Temperature is normally ambient, with occasional rise due to dumping quantities of liquids from hot equipment.

Blisters covered the bottom of Course 2 up to about a 2-ft. liquid level. One blister in each of Courses 4 and 6 was found at about the 2-ft. height above the trough. Blisters ranged from ½ in. to ¾ in. diam. and raised up as much as $\frac{1}{32}$ in. They were shallow in depth with no evidence of cracking.

No repairs were necessary but frequency of inspection was increased.

Gas Fractionation Section—Raw B-B Storage Sphere: Blisters first found in 1948 in vessel installed in service in 1943. Vessel was a 31-ft. O.D. sphere; shell plates 1¼ in. thick; 135 psi. design pressure, with a corrosion allowance varying from 0.033 to 0.10 in. Material was ASTM A-70 flange quality steel.

Vessel was used for storage of raw B-B, at ambient temperature of from 60 to 80° F. and pressure between 95 and 105 psi. H_2S content of raw B-B entering was 1.5% by volume; H_2S content of vapors at top of sphere was 6.5% by volume.

Twelve segments out of 24 making up the sphere were blistered. No blisters were found at the bottom or the top—greatest number being in the middle third of the vessel. Size varied from 1 to 4 in. diam., with up to ⅛ in. heights on the larger blisters. Blisters were between ¼ in. and ⅜ in. below the interior surface of the shell. They showed evidence of cracking on spring-line tension surfaces. The blisters apparently developed in the past year, as previous internal inspections did not reveal this condition.

Spherical segment specimens were taken to determine depths of blisters and extent of cracking, and calculations were made reducing the allowable working pressure from 135 to 115 psi. Vessel returned to temporary service with six-month inspections scheduled to watch the progress of the blisters.

Gas Fractionation Section: Raw B-B Storage Sphere: Blisters were also found in 1948 in this vessel, which was first put into service in July, 1943. Vessel is a 31-ft. O.D. sphere, with 1¼-in. shell plates, designed for 135 psi. and 0.033-in. to 0.10-in. corrosion allowance. Material was ASTM A-70 flange quality steel.

Vessel used for storing raw B-B at ambient temperature (60-80°) at between 95 and 105 psi. H_2S content of raw B-B charged to sphere 1.5% by volume; H_2S content of vapors at top of sphere 6.5% by volume.

Blisters were found on four of the 24 segments. One was 6 in. in diam. and ¼ in. high, all others were 1 to 4 in. diam. and up to ⅛ in. high. Depths were between ¼ in. and ⅜ in. below the interior surface with some minor cracking of interior faces. Bend tests on specimens indicated brittleness of metal on inside of blister, the remaining shell outside of the pocket retaining its original ductility.

Trepan sections were taken to determine the condition as a result of blistering. Working pressure was re-

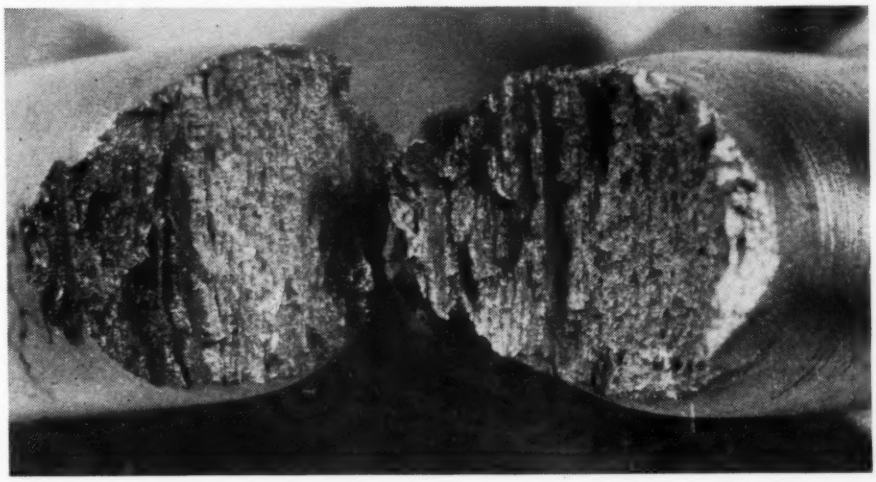


Fig. 8—Tensile fracture showing laminated structure of blistered plate (Phillips Petroleum Co. photograph)

duced from 135 to 115 psi. and the vessel was returned to temporary service, with regular inspection scheduled each six months.

Standard Oil Co. of Ohio

Distillate Debutanizer Overhead Condenser: Blisters were discovered in 1947 on the interior of the shell, the condenser having been installed in 1941. The shell is of ASTM A-70 Firebox steel plate, ⅜ in thick. The steel was bottom poured and rimmed. Stress relieving was not required but, due to unsatisfactory free and reverse bend tests, the steel would not meet the specifications until after stress relieving at 1150 to 1250° F. for ½ hour.

The condenser takes butane and lighter overhead from a debutanizer charged mainly with thermal cracking coil light distillate plus smaller amounts of crude naphtha. The overhead vapors contain 225 grains of H_2S per 100 cu. ft. of overhead gas. The hydrocarbon stream to the condenser is about 165° F. and 115 psi. Max. water temperature is about 100° F.

In one section of the plate a 4 by 4-in. blister was located. Test hole indicated the plate split about $\frac{1}{64}$ in. below the inside and $\frac{1}{64}$ in. below the outside surface. The inside surfaces of the blister spread apart $\frac{1}{32}$ in. Other portions of the exchanger, also fabricated from ASTM A-70 Firebox plate, were not blistered. An identical condenser fabricated from A-70 Firebox plate was in parallel service with the blistered condenser but to date has shown no indication of blistering.

Gulf Oil Corp.

Phenolic Water Accumulator: This horizontal vessel was installed at one of the company's southern refineries, at a Phenol treating plant and handled phenolic water at 180° F. and 0 psi. The solution in the tank contained about 15% phenol. The vessel was 5 ft. 11 in. in diam. and 15 ft. long, fabricated of flange quality steel of 55,000 psi. ultimate strength. It was neither stress relieved nor x-rayed.

Several blisters were found in one of the heads, one was 6 in. diam., another 4 in. and the rest smaller. The blisters were not felt to have seriously affected the strength of the vessel.

Phillips Petroleum Co.

In refineries blisters have been found most frequently in accumulators and feed tanks containing the lighter hydrocarbons from which hydrogen sulfide had not been removed. In HF alkylation units they have been found in the contactors, acid settling tanks, azeo feed tanks, azeo accumulators, vent gas neutralizers, acid oil legs and in anhydrous storage tanks.

A survey of 14 natural gasoline absorption plants disclosed blisters in five of the ten tanks handling sour gas, but none in plants handling sweet gas. Vessels in which blisters were most often found were make tanks, low stage accumulators, high stage accumulators, water legs just upstream from the make tanks and spheres, blimps, and cylindrical vessels storing raw natural gasoline.

Blisters have been most frequently found in A-70 Firebox and Flange quality and poorer quality steels; however, they have occurred in A-201 and A-212 Firebox quality steels. Microscopic examination of the blistered A-201 and A-212 steels showed the blistered areas to be dirty, badly segregated and to contain numerous large inclusions.

HYDROGEN EMBRITTLEMENT

Ashland Oil and Refining Co.

A number of 1-in. alloy bolts failed after 90 days' service in a light gasoline condenser. Five studs were broken when the condenser was dismantled and three others broke while removing the nuts. The bolts had corroded and pitted. Failure was in a brittle manner.

Operating conditions of the condenser were: Hydrostatic test (after assembly), 660 lbs.; Max. operating pressure, 450 psi.; Max. operating temperature, 150° F.; Gases lighter than methane, 20% (largely hydrogen); Hydrogen sulfide, 600 grains cu. ft. max.; Ammonia, small amount.

Chemical analysis of one of the studs showed it to be an AISI 4140 analysis. After removing from service, the hardness of the studs was found to range from 269 to 293 Brinell. Izod impact resistance was 80 ft.-lbs. The excellent impact resistance does not indicate that the bolt was not embrittled at one time. It is known that materials that are embrittled by hydrogen will recover ductility if removed from the embrittling medium. Also impact resistance as measured by a notched bar broken at high velocity has been found to have practically no correlation with hydrogen embrittlement.

On etching one of the smooth fractured ends of a failed bolt, the grooves shown in Fig. 9 developed. It was felt that this peculiar etching was caused when hydrogen, in embrittling the bolt, had opened up cracks that permitted attack by the etchant below the apparent fracture surface. If true, this observation offers a method of identifying steels which have failed from hydrogen embrittlement.

Phillips Petroleum Co.

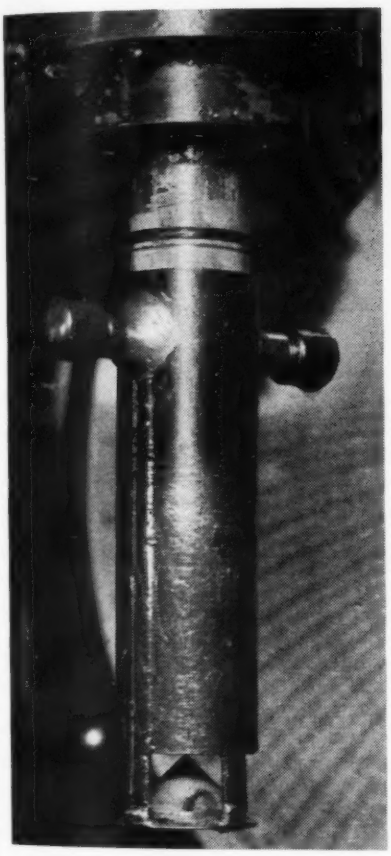
Breakage had been reported of 12% chromium steel springs in valves handling water saturated with hydrogen sulfide at 40 to 100° F. in as little as three hours' time. Extensive breakage of 12% chromium steel bourdon tubes and relief valve springs has troubled gasoline plants in West Texas and New Mexico. Sucker rods pumping sour wells have become glass-like brittle. These recovered their ductility after being removed from the wells and left idle a few days. Brittle bolt failures have been found in equipment handling sour hydrocarbons. High strength bolting, hard lock washers and hardened plug valves crack in equipment handling sour hydrocarbons, or mixtures of hydrocarbons and hydrofluoric acid.

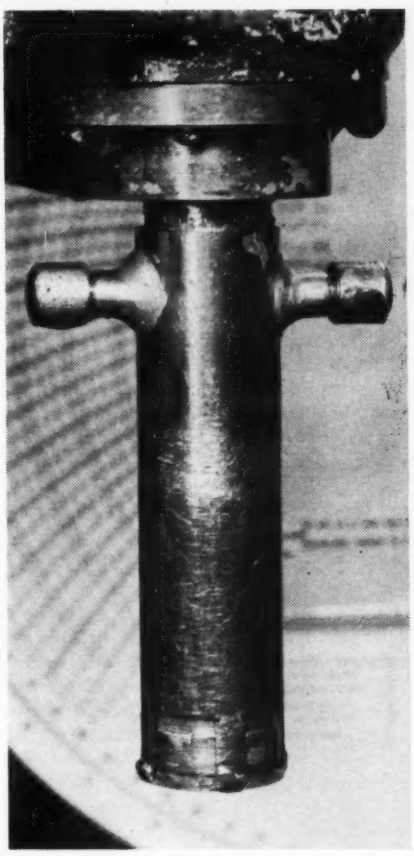
Fig. 9—Fractured end of bolt that failed in brittle manner. Before etching this end was smooth (Ashland Oil and Refining Co. photograph)

Plant Practices

Practical Tips and Ideas for Improving Operations

Non-drip Spout Cuts Waste to Minimum From Lube Oil-drum Filling Machines





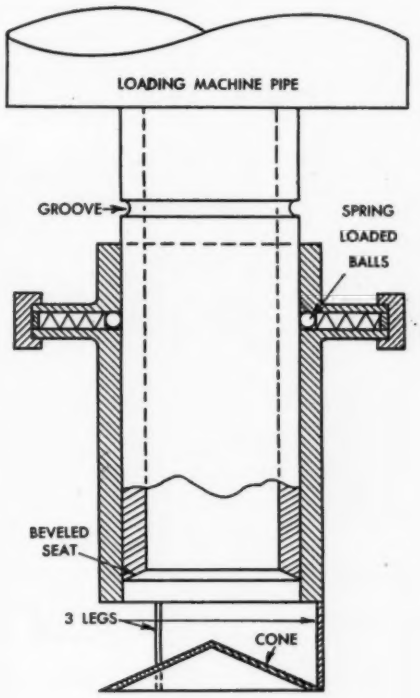


Fig. 1—Anti-drip device used on drum-filling machine at Gulf Oil's Philadelphia plant. Sketch above shows method of construction. Photograph at far left shows nozzle in open position, that on right shows nozzle closed

CONTINUAL dripping from conventional spouts on drum loading machines in the lube oil packaging department at the Philadelphia refinery of the Gulf Oil Corp. not only was wasting valuable product but also made housekeeping an extremely difficult, if not impossible, task. Operators had to keep rags on hand all the time to wipe off drum tops, roller conveyors, and the floor between each filling operation.

An improved nozzle, designed and built by Gulf engineers, now keeps drippage to an absolute minimum. Illustrated in the sketch in Fig. 1, it consists of two slip-fitted pieces of copper tubing slightly smaller in diameter than the bung-hole, and with a beveled seat and cone arrangement on the lower ends to serve as a simple valve.

A spring-loaded ball-and-groove lock keeps the cone snug up against the beveled seat on the inner, stationary tube between each filling operation. During filling, the outer tube is lowered inside the bung-hole in the drum so that the two projecting arms rest against the top of the drum.

Electrically-heated Oil Bath Eases Job Of Shrink-fitting Bearings on Shafts

AN OLD square metal can and a discarded electric heating coil have been combined to build a simple, safe and efficient oil bath for use in shrink-fitting bearings on electric motor shafts in the electrical shop at Ashland Oil & Refining Co.'s Catlettsburg, Ky., refinery.

As shown in the accompanying photograph, the device consists principally of a metal can which will hold several quarts of oil, and a metal-encased electric heating unit in the base of the can. Thermostatically controlled, the unit will hold the maximum temperature to 250° F., following manufacturer's recommendations.

The can is equipped with a steel safety lid which will automatically close and smother out any fire if the oil were ignited. The lid normally is open, supported by a metal link which will melt at 300° F. and allow the lid to drop shut.

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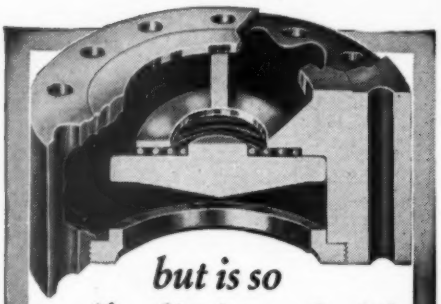

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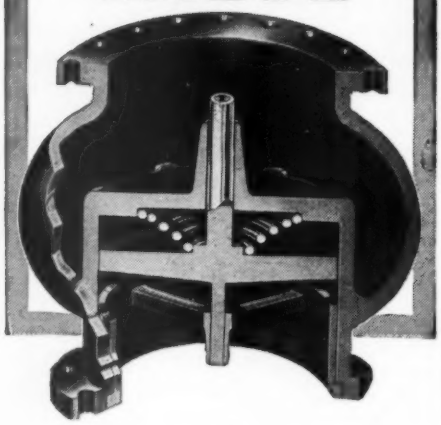

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Ashland's shop-built oil-bath (right background) used in shrink-fitting bearings

trician E. K. Clere, the oil bath greatly simplifies work on motor shafts and assures the department that the bearing will go into service without having been damaged by hammer blows or dirtied by dust and grit.

Powered Straddle Trucks Found Useful In Refinery for Handling Tube Bundles

"STRADDLE" trucks, well-known for their use in the lumber industry, have been put to use for material handling chores at the Philadelphia refinery of Atlantic Refining Co. They carry heat exchanger tube bundles, pipe, and miscellaneous supplies and equipment.

The straddle truck resembles a small roadster on stilts. The power unit, cab, and operator are on an elevated chassis about 8 to 10 ft. above the ground. In use for handling lumber, it is driven over a pile of lumber so that it straddles the load; four lifting prongs are swung under the pallet on which the lumber is piled, the prongs are raised and the load is taken away. The space between the prongs is approximately 5 ft., and they will handle a load not less than about 12 ft. long.

Atlantic's use of the trucks is shown in Fig. 2. A bolster or cradle for the tube bundle is constructed of 10 by 10 in. timbers. The truck is operated the same as with a load of lumber. Tube bundles up to any usual length, properly laid on the bolsters, have been transported in this method by Atlantic.

For miscellaneous objects; pipe and the like, the company uses open-end wooden tote boxes about 5 ft. wide and having 3 ft. high side walls, as illustrated at the right in Fig. 2.

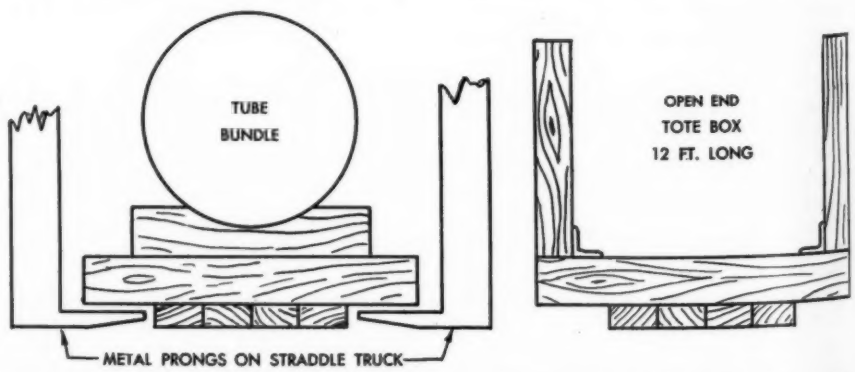

Fig. 2—Special tube bundle bolster and tote box enable Atlantic Refining Co. to employ "straddle" trucks for material handling

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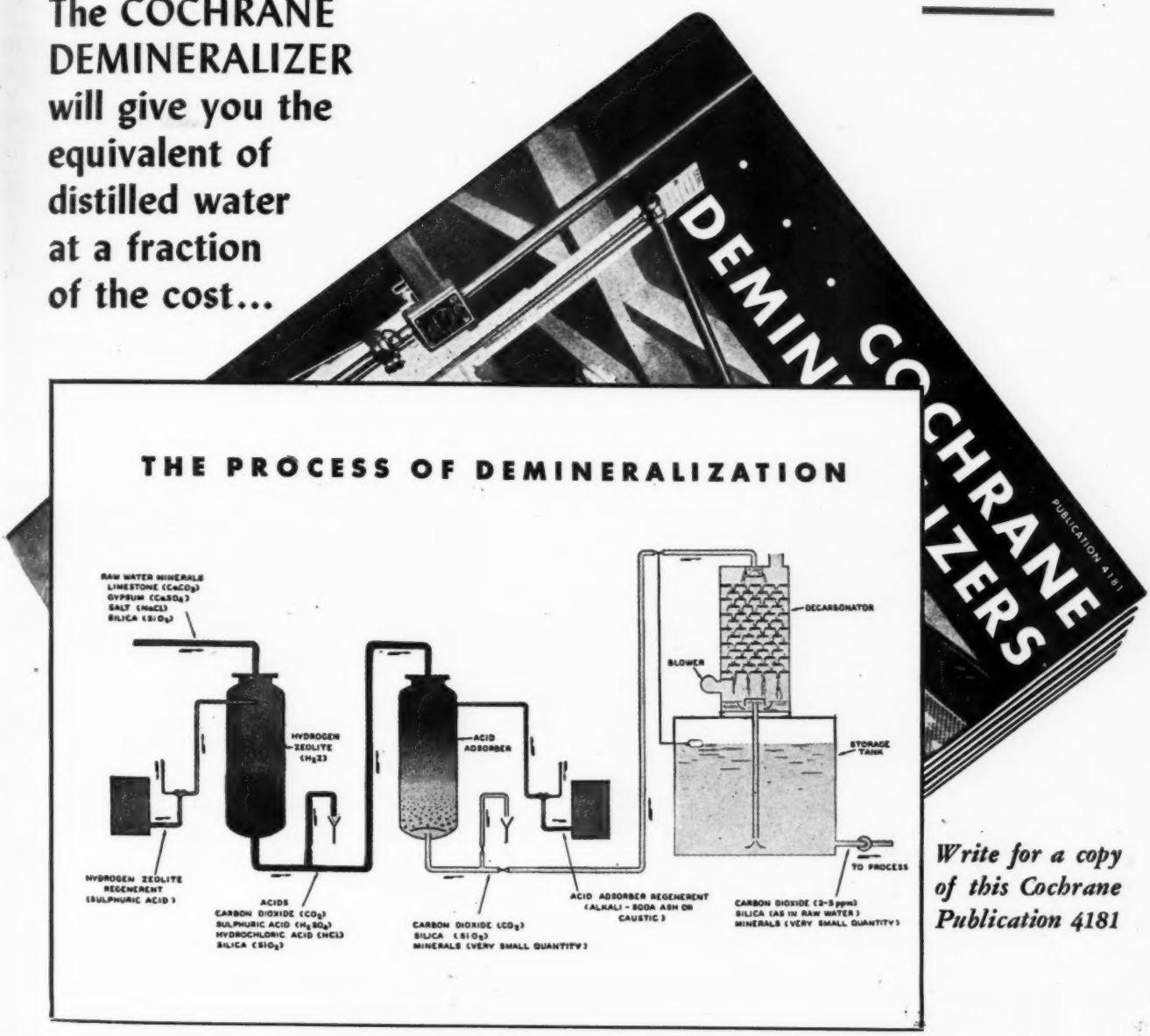

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Laboratory Practices

Conventional Engine Test Not Required In Procedure for Additive-type Lubes

A NEW evaluation test for additive-type lubricating oils, said to simulate the characteristic results of conventional engine tests, has been developed in the lubrication laboratory of the National Bureau of Standards by S. A. McKee and Ann Robinson Fritz.

Requiring only a simple piece of laboratory apparatus, the new method is time saving and less expensive than the present procedure, which involves tearing down the test engine and examining its parts. It eliminates the fuel variable normally encountered in the conventional method, where oil may become contaminated by the engine fuel. The Bureau states it is a sensitive measure of the effectiveness of an additive in motor oil and it will give a quantitative as well as a visual rating of an oil, thus providing more consistent results and reducing the variables caused by individual test operators.

It is believed the stability test also may prove useful as a quick check for control purposes, where the cost of running engine tests may be prohibitive.

The new test method consists essentially of circulating the oil sample in a thin film over a heated steel strip, quite similar to the oil film on an engine cylinder wall. A mechanical lubricator pump delivers the oil from a small glass container to the upper end of the thin steel strip which is held in an inclined position and maintained at the test temperature. The oil leaving the lower end of the plate drops into the reservoir and is recirculated. The amount of deposit on this strip provides a sensitive means for rating the lubricating oil under test.

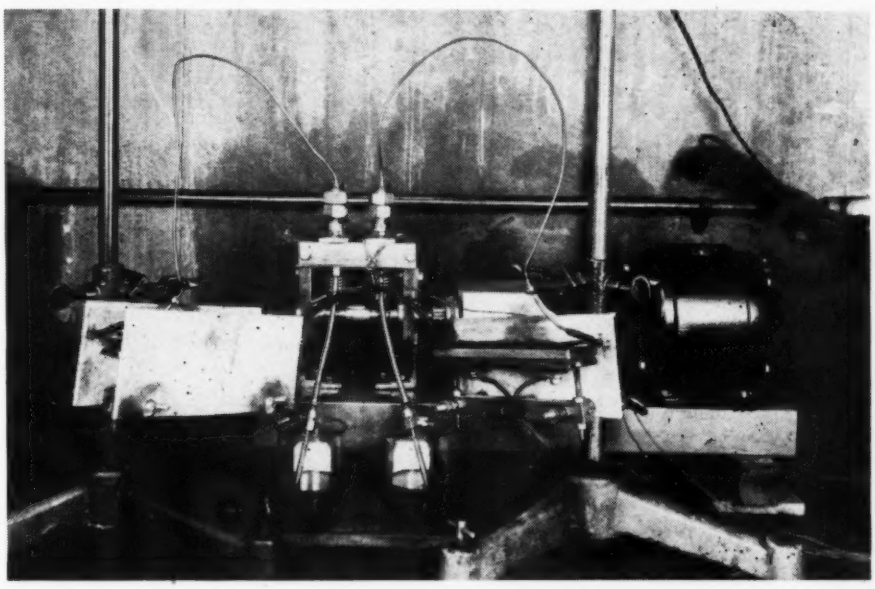
The steel strip is heated by a 7-in., 200-watt electric heater supported in such a manner that the upper surface of the heater may be inclined at any desired angle toward the reservoir of test oil. The test specimen, 9 in. long, 1¾ in. wide, and 1/32-in. thick, is fastened to the top of a copper bar which is clamped to the heater. A steel overstrip 3 in. long, 1¾ in. wide, and 1/32-in. thick is fastened at the upper end, overlapping the test strip by 2½ in. A piece of doubled 20-mesh steel wire screen is placed on the overstrip to assist in spreading the oil evenly on the test strip.

Tests are usually carried out with two units simultaneously. The circulating pump for each unit is operated by a common camshaft driven by a ⅛-hp electric motor through a 100 to 1 gear speed reducer. The camshaft, turning at 18 rpm, has 2 cams for each positive displacement pump, which therefore operates at 36 displacements per minute. The suction line of the pump is fitted with a fine wire-mesh strainer which is immersed in the reservoir of test oil and the discharge is through ⅛-in. copper tubing. This may be adjusted to conduct the oil to the overstrip during a test run or to one side for cleaning or calibrating operations. A special head of ¼-in. copper tubing, compressed at one end to form a slit 1/32 x ½ in., is fitted over the tubing that delivers oil to the overstrip.

The test temperature is measured by a thermocouple inserted in the side of the copper bar at midpoint and is controlled manually by a variable transformer in the line to the heater. The complete assembly is enclosed in a hood with a restricted air inlet so that fumes are removed from the room, but no forced draft is used. This arrangement provides a considerable degree of flexibility. The temperature of the strip may be changed by regulating the transformer. The film of oil flowing down the strip may be varied by changing the slope of the strip, and by adjusting the stroke of the pump to change the rate of circulation.

In general, the oils used in the Bureau's investigation are in commercial production and have a considerable background of service performance. They include oils with no additives, premium-type additive oils containing inhibitors and/or detergents, and full heavy-duty oils containing additives that meet U. S. Army Ordnance 2-104B and Navy 9000 series specifications.

The Bureau's tests were made with weighed samples of 150 ml. of oil in 250-ml. beakers under the following conditions: Temperature, 250° C; oil delivery, approximately 0.7 grams



NBS apparatus for laboratory evaluation of stability of additive-treated lube oils. Oil from a beaker reservoir (center) flows in a thin film at a regular rate over a weighted steel strip which is maintained at an elevated temperature. The oil is recirculated by the motor, pumps, and tubing (background). The shields on the sides of the strips and heater assemblies prevent air currents from affecting results (one of the shields at the right has been removed)

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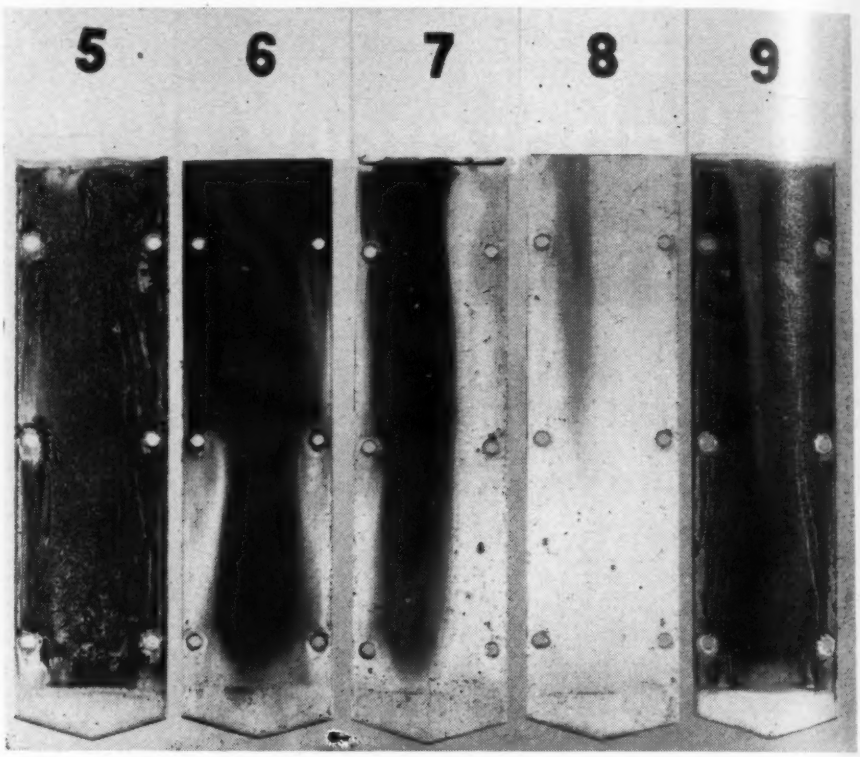


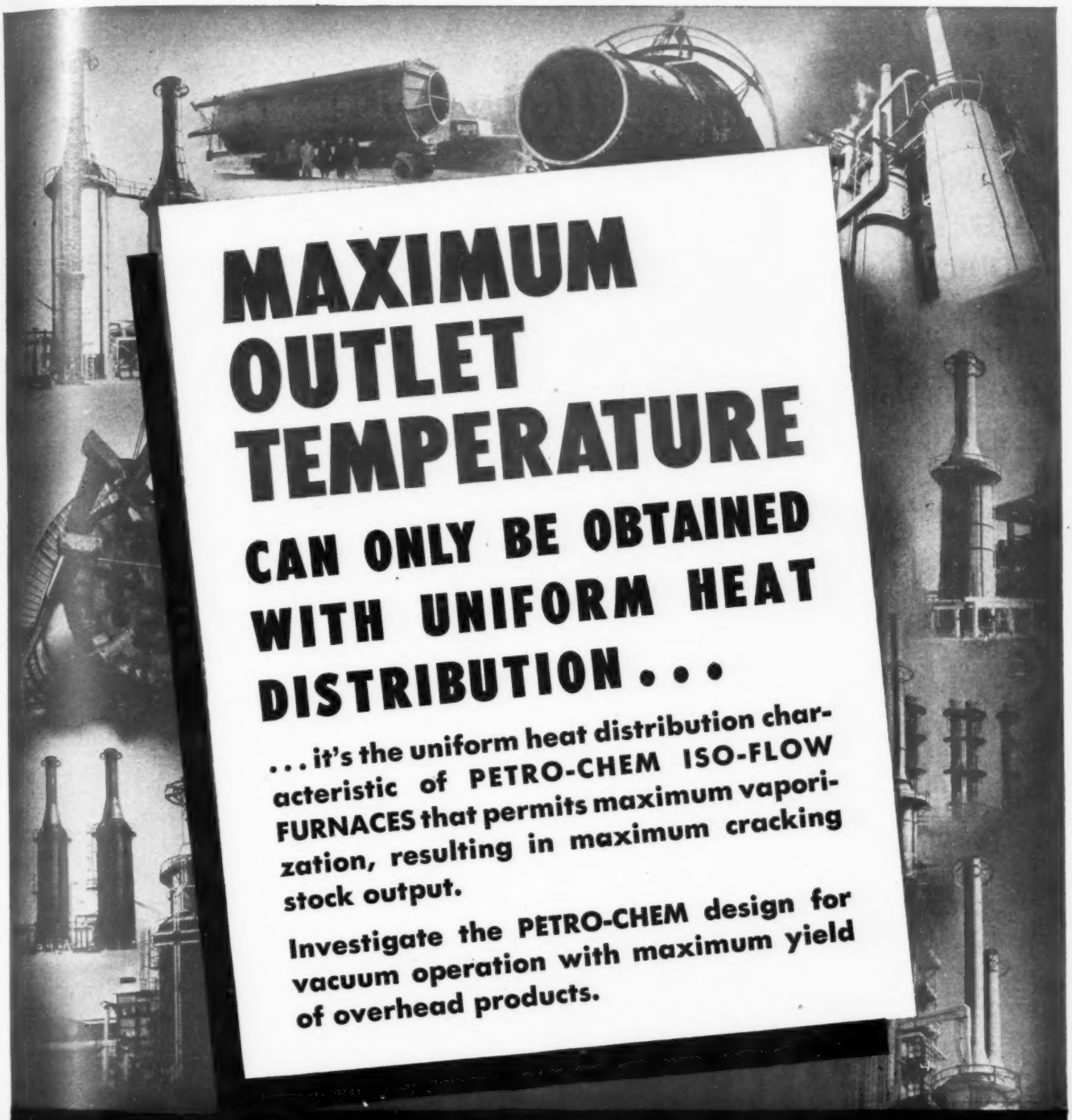
Set of test strips showing effectiveness of various additives on a mid-continent, solvent-extracted lube oil. Formation on strip 5 resulted from a straight oil (no additive), while sample 6 contained an oxidation inhibitor but no detergent; sample 7, a premium additive with some inhibitor and detergent; sample 8, a premium additive with full amount of inhibitor and detergent (U.S. Army Spec. 2-104B); and sample 9, detergent but no inhibitor

per minute; and slope of strip, 8.5 degrees from the horizontal. This temperature approximates the high temperature regions in the engine under full power operation. After a heating-up period of about one-half hour, the apparatus is held at the test temperature during a 6-hr. run. The test strip is then removed and drained overnight in a vertical position. After cleaning the back of the strip with a naphtha-moistened cloth, the strip is weighed. Following this the copper bar, screens, and steel screen are cleaned and the strip is again secured in test position for a second 6-hour run. The test completed, the strip is removed and allowed to drain at least 24 hours before cleaning the back and weighing.

The difference in weight of the strip before and after the test provides a numerical indication of the amount of deposit formed, but these values are influenced by any oil remaining on the deposit. However, the oil may be removed by a simple method. The test strip is supported in a slightly inclined position over a waste pan and a piece of cotton gauze placed across the strip near the top. A container of precipitation naphtha is located slightly higher than the strip with a wick of gauze from the container feeding naphtha to the gauze on the strip. This provides an even, gentle flow of naphtha down the strip but does not disturb the deposit. When the naphtha dripping from the strip is colorless, the gauzes are removed and the strip dried and weighed. After the test, the oil remaining in the container is weighed, the loss in weight providing an approximate indication of the evaporation loss. The viscosities at 100° F. are also measured before and after heating.

Data obtained with the new test give a sensitive indication of the effectiveness of inhibitors, detergents, and their combinations. The particular conditions under which the Bureau tests were conducted tend to accentuate the effectiveness of full heavy-duty additive oils. The apparatus is sufficiently flexible, however, to cover a wide range of conditions which might be more suitable for premium grade oils or which would give additional information on the overall effectiveness of a given oil-additive combination.

The correlation of the laboratory stability test with engine performance is sufficiently satisfactory to justify further work. In this connection, an automatic temperature control is being provided so that the test may be run overnight and hence reduce the time of test in terms of work days.



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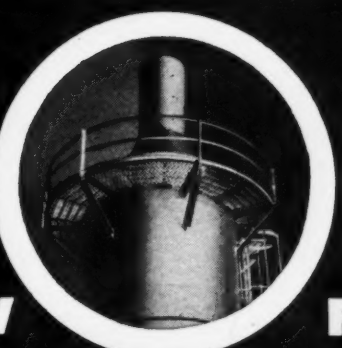

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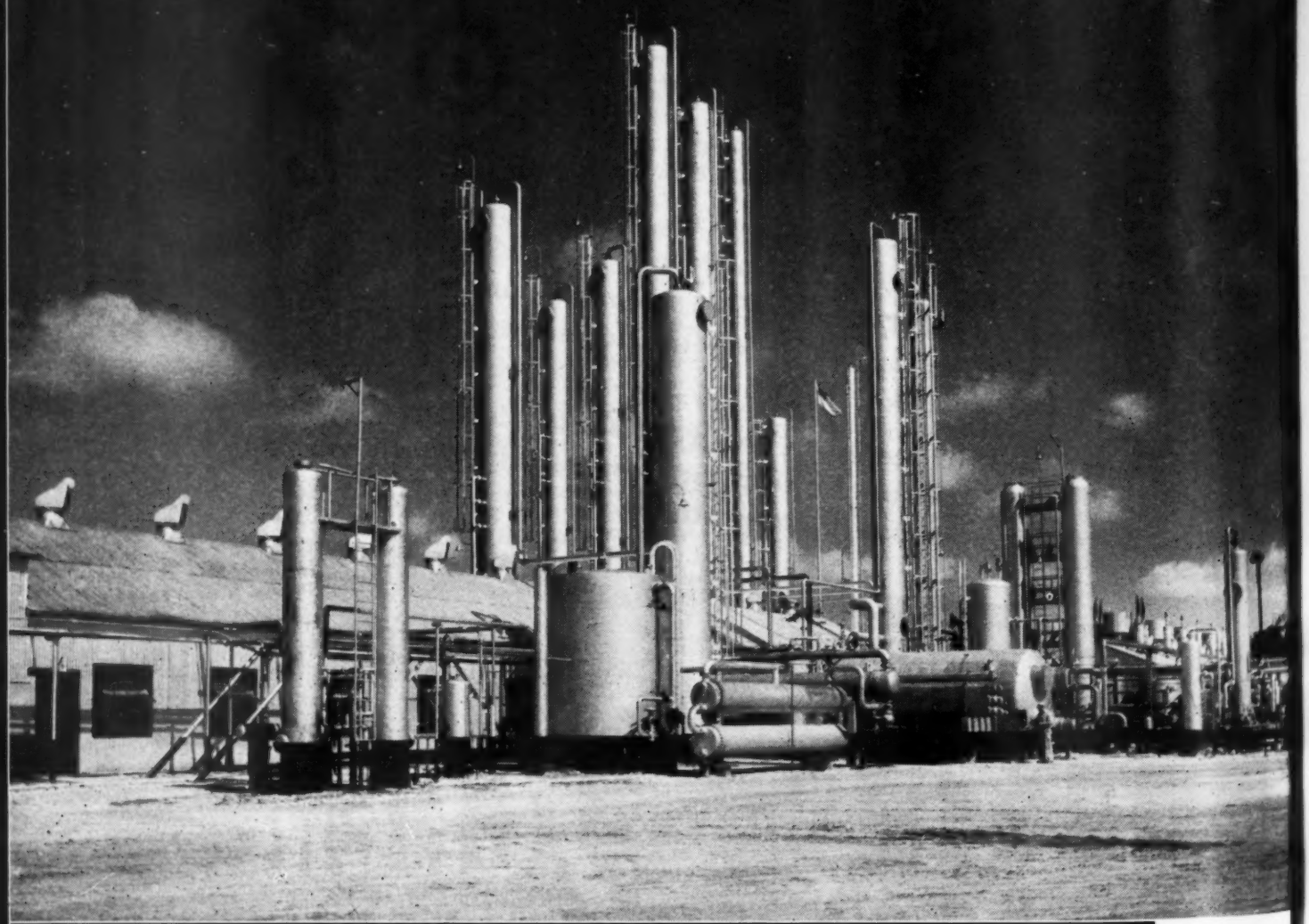

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Crude Oil, Natural Gasoline and Liquefied Petroleum Products

Patent Trends in Petroleum Refining

By Peter J. Gaylor, Editor "The Technical Survey"

Recent Isomerization Patents

THE petroleum refiner generally looks at isomerization as the conversion of a normal paraffin hydrocarbon to an isoparaffin, with a resulting increase in octane number. Broadly, however, it can be looked upon as any change in the skeletal structure of the molecule without loss of carbon or hydrogen and, of course, preferably with increase in value. Such value may be other than octane appreciation, as in the case of converting n-butylene to isobutylene which can be used in butyl rubber production.

Isomerization reactions of pure hydrocarbons might be classified in the following categories:

1. Increasing branchiness
2. Shifting unsaturated bonds
3. Shifting alkyl groups
4. Changing the nature of the carbon skeleton (cyclic form)
5. Changing geometric configuration.

The first of these operations is the most important in the fuel field, since the increase in branchiness (or compactness) gives a decided increase in octane number.(1) For example, this can be adequately illustrated by comparing the octane numbers of the pentanes:

	Oct. No.
n-pentane	60
iso-pentane	92
neo-pentane	116

Obviously, the process is of considerable importance in the aviation industry, and great interest has been shown in the commercial production of neopentane (2,2-dimethyl propane), neohexane (2,2-dimethyl butane), triptane (2,2,3-trimethyl butane), and, of course, isooctane (2,2,4-trimethyl pentane). Also, since there is a shortage of isobutane and isopentane, it is of value as an adjunct to alkylation and polymerization.

Although paraffins can be isomerized thermally, such an operation is accompanied by considerable cracking, so that catalytic conversion is resorted to in commercial operation. This might be illustrated by the fact that thermal isomerization of n-octane can be carried out to the extent of 10%, but with considerable cracking, whereas with aluminum chloride as catalyst, a conversion of 31.7% can be obtained with considerably less cracking, at 50-60° C. The main criterion in commercial considerations is the number of gallons of isomer which may be obtained per pound of catalyst.

One Shell Development Co. patent(2) discloses the use of alumina impregnated with aluminum chloride, as catalyst, using hydrogen chloride as the promoter. With n-butane, at below 200° C. and 5-20 atm. pressure, the reaction is mildly exothermic, giving a 40-45% yield of isobutane per pass. Presence of hydrogen has been found to promote catalyst life.(3) The firm later employed an aluminum chloride-antimony trichloride-hydrochloric acid liquid catalyst.

Standard of Indiana's Isomate process has been used "to convert straight run gasoline of 65 octane to 81 octane number, with 98% yield", using temperatures below 300° C.

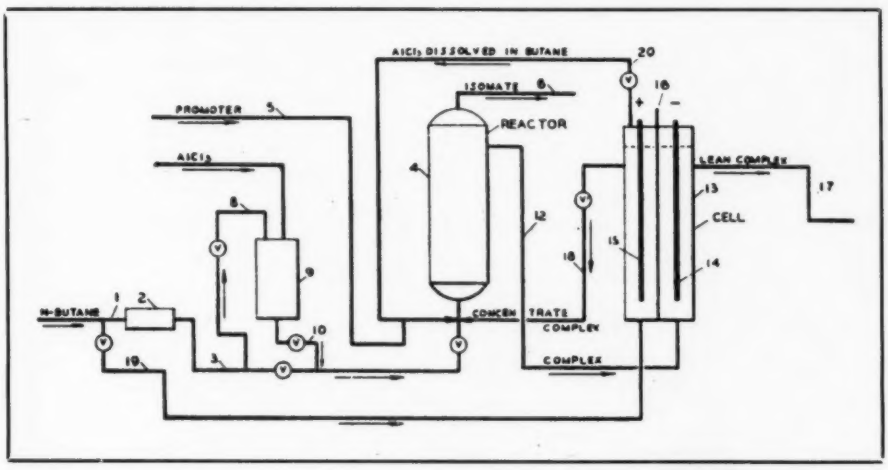


Fig. 1—Flow diagram of an isomerization process employing electrolysis of halide complex. (The Texas Co., U. S. 2,463,610)

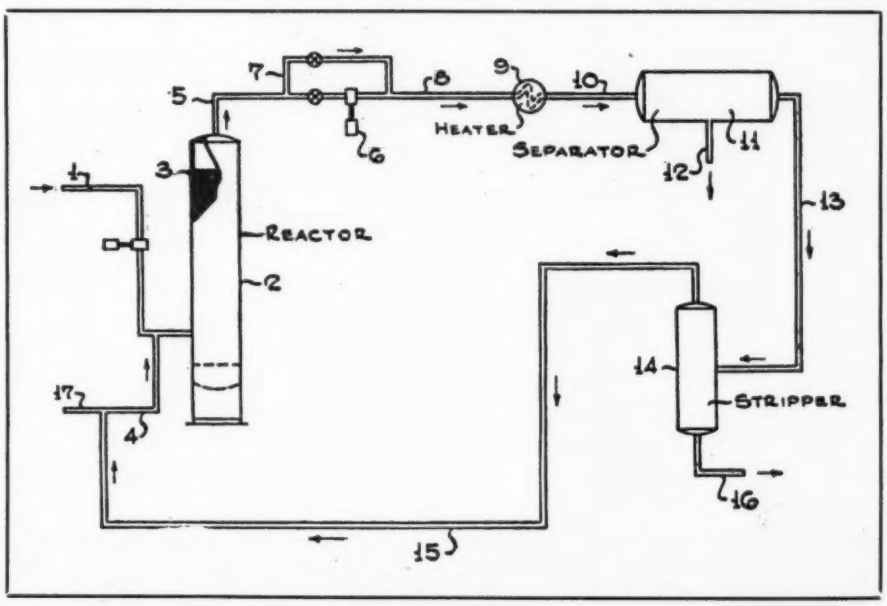


Fig. 2—Flow diagram of a method for heating an isomer steam near critical state to separate halide catalyst. (Standard Oil Development Co., U. S. 2,471,054)

Only isomerization of straight chain paraffins is claimed. The catalyst is said to be an active halide. Patents[4] show that recycle of propane and some butane in the isomerization reaction is beneficial, using 300°-550° C. and 500-600 psi., with propane recycle being up to 35% of the charge. One patent[5] indicates that under such conditions propane reacts with ethane and with itself to produce isobutane. Propane alone passed over a catalyst, with 10% hydrogen chloride, gave a product containing over 11% isobutane.

A Shell British patent[6] describes production of 59% isohexanes by passing n-hexane, hydrogen and aluminum chloride at 80° and 45 atm. in a V2A reactor.

Olefins also may be isomerized by increasing branchiness. For example, n-hexene is converted to dimethyl ethyl ethylene (23%) in presence of phosphoric acid on pumice at 335° C. and 60 atm. Also, isobutane may be obtained from n-butene and hydrogen under similar conditions.[7] When passed over alumina, olefins tend to assume a more compact configuration and they are easier to isomerize than paraffins.

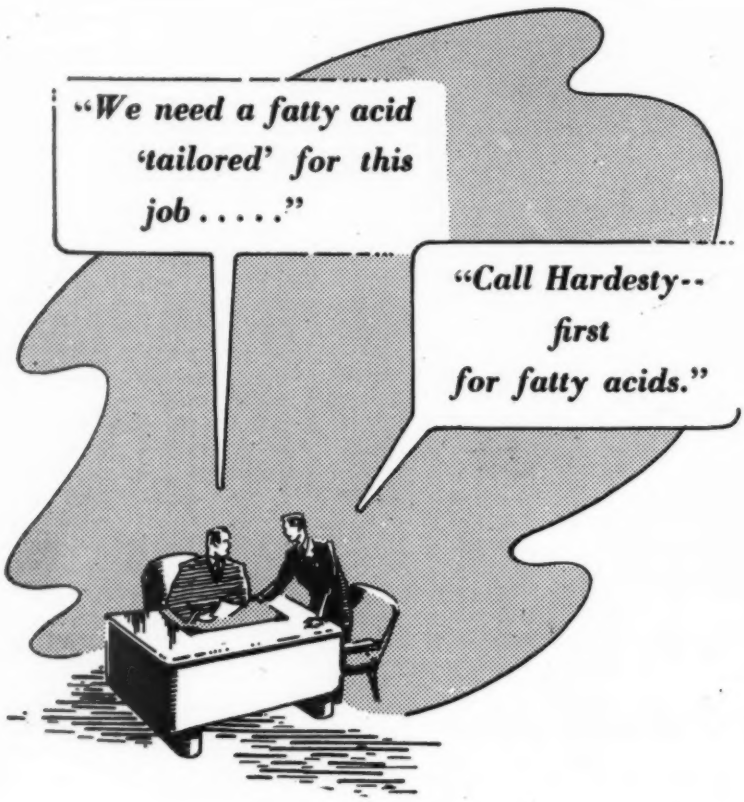
Among the more recent patents,[8] is one obtained by The Texas Co. on the isomerization of butane. The flow sheet, shown in Fig. 1, describes passing the n-butane feed 1 in liquid phase in contact, in reaction zone 9, with a body of alumina chloride-paraffin hydrocarbon complex liquid containing uncombined aluminum chloride, together with promoter 5 into a reactor 4 from the top of which the isomate 6 is removed, and a complex stream 12 is drawn off and led into a zone of electrolysis 13, together with a stream of n-butane 19. In the cell 13, a complex rich in uncombined aluminum chloride content is separated and recycled to reactor 4, while a lean complex is discarded through line 17.

Another patent,[9] to Phillips Petroleum Co., describes passing the isomate, leaving the reactor, through a bed of sodium acid sulfate at isomerization temperature to effect further isomerization. Universal Oil Products Co. covers isomerization in presence of a catalyst prepared by reacting boric acid and a metal halide of the Friedel-Crafts type, hydrogen halide being evolved during the reaction.[10]

Normally liquid paraffins having at least 10 carbon atoms per molecule have been isomerized[11] in presence of a carbon decomposition suppressor (saturated cyclic hydrocarbon) with a preformed metal halide complex at 20°-150° C. Such a product would be suitable as a diesel fuel.

In a recent Standard Oil Development Co. patent,[12] the flowsheet for which is shown in Fig. 2, the isomerized stream 5 leaving reactor 2 is heated at 9 to a temperature near but not above the critical temperature, with sufficient pressure (from pump 6) to maintain a liquid phase, and passed into separation zone 11 in which a phase rich in aluminum halide separates out and is removed through line 12, while the product phase, relatively free of aluminum halide, is drawn off and fractionated in stripper 14.

A Socony Vacuum Oil Co. patent[13] discloses conversion of straight chain olefins having not over 6 carbon atoms, into branched chains, by contacting with a catalyst consisting essentially of alumina impregnated with hydrofluoric acid.



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References

(1) Gaylor, *Petr. Engr.*, 12/46, p.790; 3/47, p. 72.
(2) U.S. 2,208,362 (Shell Dev. Co.).
(3) U.S. 2,271,403 (Shell Dev. Co.).
(4) U.S. 2,266,011-2 (Shell Dev. Co.).
(5) U.S. 2,270,669 (Shell Dev. Co.).
(7) Ipatieff and Pines, *Ind. Engrg. Chem.*, 27, 1369 (1935).
(8) U.S. 2,463,610 (Texas Co.)
(9) U.S. 2,464,201 (Phillips Petr. Co.).
(10) U.S. 2,467,326 (Univ. Oil Prods. Co.).
(11) U.S. 2,468,746 (Shell Dev. Co.).
(12) U.S. 2,471,054 (Standard Oil Dev. Co.).
(13) U.S. 2,471,647 (Socony Vacuum Oil Co.).

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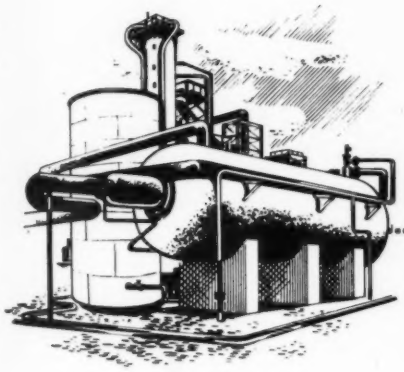

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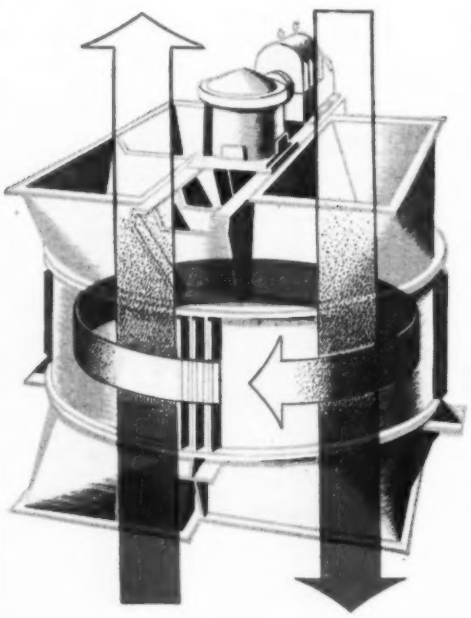

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Excess Flow Valve Is Designed To Prevent Small Gas Leaks

In addition to the improved excess flow valve described below, this month's review of new and improved devices used in petroleum processing and handling operations on which patents have been issued recently includes a rotary mechanical seal for propane pumps.

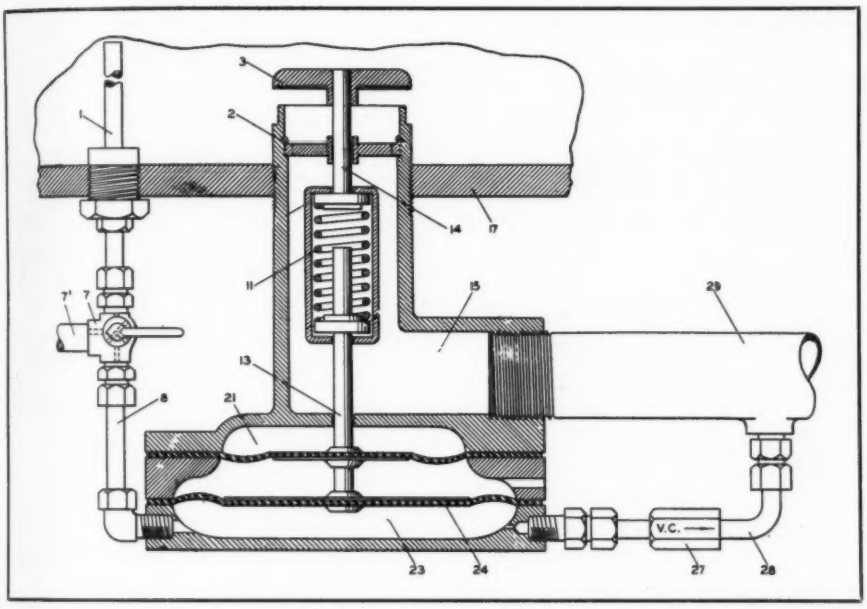

Fig. 1—Improved excess flow valve for LPG vessels (U. S. 2,472,070)

DUAL DIAPHRAGM CONSTRUCTION is utilized in an internal excess flow valve for liquefied petroleum gas containers, truck tanks, and the like, which is said to overcome the disadvantage of conventional valves of this type—permitting small leaks not of sufficient magnitude to close positively the excess flow valve. Such partial leaks result eventually in a fire or explosion hazard and, if prolonged, in a waste of valuable product.

A valve of the dual diaphragm design also may be used in liquid outlet lines from any closed vessel containing liquid and gas, vapor, or air under pressure, it is claimed.

Operation is illustrated in Fig. 1, in which the vessel 17 contains liquid and vapor under pressure. Starting with valve head 3 lowered against body member 2 to close conduit 15 and outlet line 29, the three-way control valve 7 is manually turned to connect lines 1 and 8. Gas under pressure flows from the vapor space of vessel 17 to the lowest diaphragm chamber 23. Here its pressure actuates diaphragm 24, pushing thrust pin 13 upwardly. This movement transmits pressure, via spring 11, to valve stem 14, tending to open valve head 3. Opening, however, is prevented because of liquid pressure in vessel 17.

Gas in chamber 23 flows through check valve 27 and line 28 to outlet line 29 and the conduit 15. When gas pressure in conduit 15 becomes great enough to enable spring 11 to overcome compression, valve head 3 is lifted. In this position, the valve functions as an excess flow valve. A break in outlet line 29 allows pressure to be reduced in conduit 15 and the liquid pressure in vessel 17 once more closes valve head 3.

The valve can be closed at will by turning valve 7 to vent chamber 23 to the atmosphere through line 7'. Pressure in chamber 21 is approximately equal to that in conduit 15 since pin 13 is not sealed gas tight with the wall of conduit 15. This pressure forces pin 13 downward, thus closing valve head 3 and maintaining it in a closed position because of the liquid pressure in vessel 17.

U. S. 2,472,070, issued June 7, 1949, to Owen L. Garretson, assignor to Phillips Petroleum Co., Bartlesville, Okla.

Lubrication, Cooling Features Of Propane Pump Shaft Seal

A ROTARY MECHANICAL seal has been designed for the shaft of a centrifugal pump handling propane and the like, which is balanced and cooled, and also may be lubricated. The washers are not required to rotate and yet are free to move axially so as to compensate for wear or axial vibrations of the shaft.

As illustrated in Fig. 2, the pump shaft 10 has a conventional sleeve 11, an outer seal sleeve 12, O rings 19 and 20, and a retaining collar 21, made preferably of Stellite or other hard ferrous materials. Carbon sealing washers 25 and 38 complete the major parts of the internal assembly. Washer 25 is cooled by means of water which passes through port 37 and enters the groove 36 between O rings 32 and 33. Lubrication is provided for the normally rotating parts by passing oil in

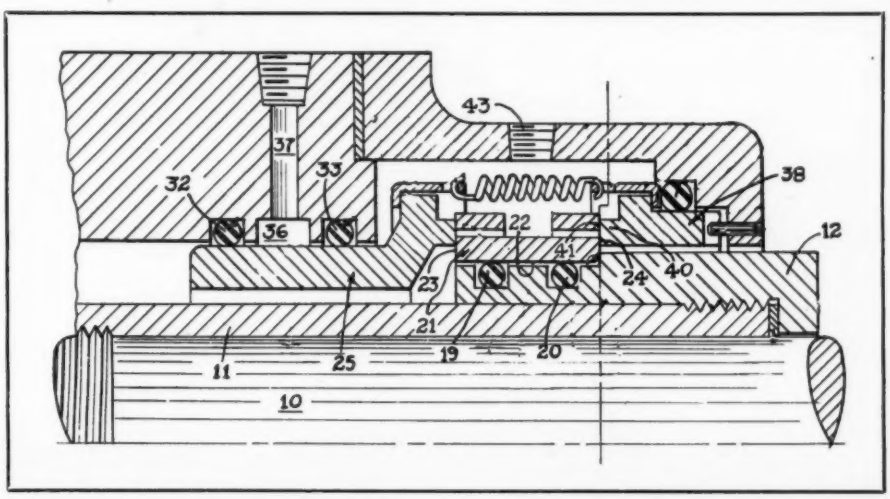

Fig. 2—Lubricated and cooled seal for propane pump shaft (U. S. 2,470,419)

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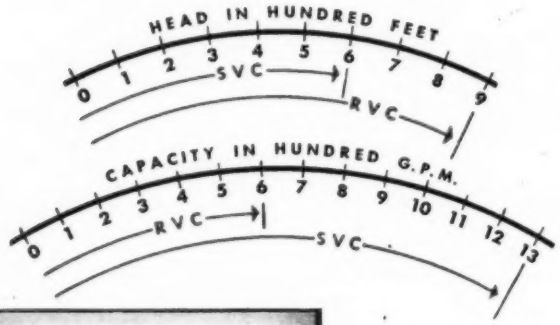

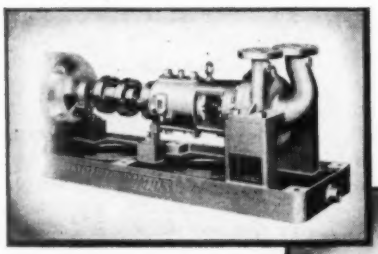

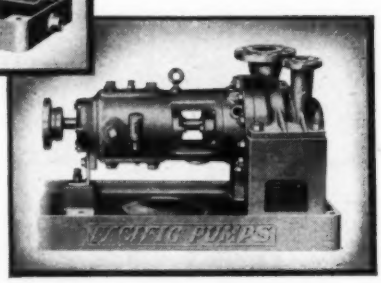

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through opening 43 so as to reach wearing surfaces 23 and 24.

U. S. 2,470,419, issued May 17, 1949, to Charles F. Voytech, assignor to Crane Packing Co., Chicago, Ill.

Other Recent Patents

Space does not permit the complete review of all patents issued recently on equipment for the petroleum processing industry. Following, however, are brief abstracts of those with the greatest interest.

Dry Chemical Fire Extinguisher in which the dry chemical storage bin is designed with a series of tangentially entering nozzles from the high pressure gas supply, providing for thorough and complete transfer of the chemical from the reservoir to the fire. U. S. 2,473,349, issued June 14, 1949, to Ward E. Snowden, assignor to Snowden Chemical Co., Modesto, Calif.

Catalyst Stripping Vessel which is divided into a series of zones by spaced, horizontal, perforated baffles such as subway grating, so as to insure efficient staging and obtain countercurrent stripping action on the hydrocarbon vapors. U. S. 2,472,502, issued June 7, 1949, to Charles W. Tyson, assignor to Standard Oil Development Co.

Cyclone Separator for catalyst dust, of high efficiency, utilizing a double cone design with internal baffles and tangential openings, said to eliminate the necessity for secondary or "clean up" equipment normally used. U. S. 2,472,777, issued June 7, 1949, to David H. Putney, assignor to Stratford Development Corp., Kansas City, Mo.

Feeding Mechanism for adding powdered dyes to motor gasolines, in which contamination of the air in the surrounding working space is avoided, and losses in transferring the dye from storage containers are kept to a minimum. U. S. 2,473,474, issued June 14, 1949, to Charles C. Keane, assignor to Great Lakes Pipe Line Co., Kansas City, Mo.

How to Obtain Patents

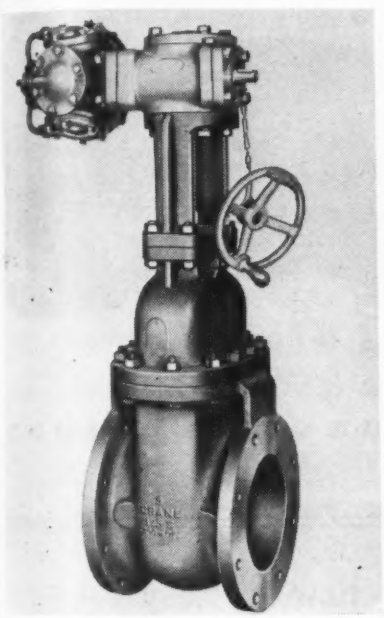
Readers may obtain copies of any U. S. patents from the Patent Office at 25 cents each. Order by patent number direct from: The Commissioner of Patents, Washington 25, D. C.

What's New!

EQUIPMENT . . . MATERIALS . . . PROCESSES . . . LITERATURE

Reviewed by WILLIAM C. UHL, Equipment Editor

1—Gate Valve Actuator

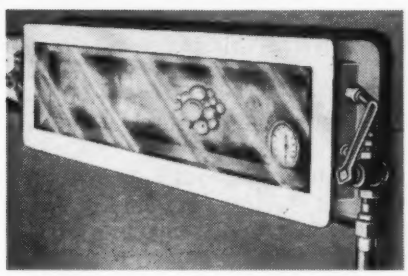


The new Crane fluid-motor operator for gate valves makes possible extensive use of motor operated valves, because the actuating unit can be adapted easily to standard valves in stock or to valves already installed. Previously, motor-operated valves were customarily made up on special order to the requirements of the installation. The device can be operated by water, oil, compressed air, or gases. The unit, comprising motor, gear box and yoke, is bolted to the valve bonnet; and the motor operates the valve stem through the gear box, deriving its power from five flexible diaphragms, mounted radially about an eccentric on the drive shaft. Operating fluid is admitted in rotational sequence to the five diaphragms, which actuate pistons that transmit the thrust to the eccentric through a roller bearing mounted on the shaft. Sizes available range from 4 to 30-in. Development is in progress on a motor for valves of still larger sizes. Crane Co.

For More Information

Use one of the attached reply cards to request additional information or literature on any items reviewed in "What's New!" Just circle the numbers corresponding to the numbers on the items you're interested in, fill in the rest of the card, and drop it in the mail. No postage required.

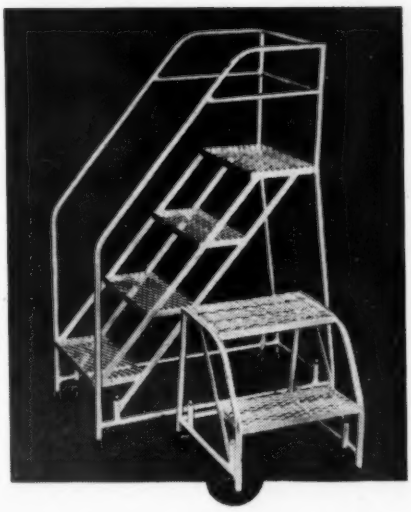
2—Portable Leak Detector



The American Vacuum Seam Tester is a portable device for quickly locating leaks in pipes and tanks, and is said to detect even the smallest pin-point leaks by the simple vacuum principle. Seams are covered with soap suds and the inspection box, with a clear glass top and soft rubber base, is laid over the seam. A strong vacuum created within the inspection box draws air or gas through any leaks, causing soap bubbles to form. Testers are available in a wide variety of sizes and shapes for inside corners, outside corners, circumferential seams, and straight seams. The device is said to be valuable in checking tank decks and bottoms as well as piping. American Pipe & Steel Corp.

3—Safety Step Ladder

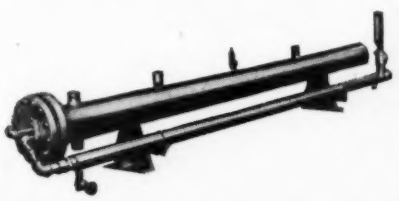
An automatic safety feature is claimed for the new Ballymore Mobile Safety Step Ladder. It is mounted on ball bearing casters for easy movement, but when a person steps



on the ladder, rubber-tipped legs automatically drop down into contact with the floor, preventing rolling action and the possibility of a fall due to the ladder moving. The ladders are made in standard sizes with from one to six steps, in aluminum finished steel. The frame is ¾-in. steel tubing and step plates are of non-slip, reinforced, expanded steel, electrically-welded. Handrails are optional on ladders having from three to six steps. The Ballymore Co.

4—Small Boiler Blowdown

The Henszey Packet Type Continuous Blowdown, designed particularly for small plants under 500 hp., is said to be completely automatic, giving a definite and correct blowdown regardless of variations in boiler load. The unit is self-contained and arrives at the point of installation ready to operate. Henszey Co.



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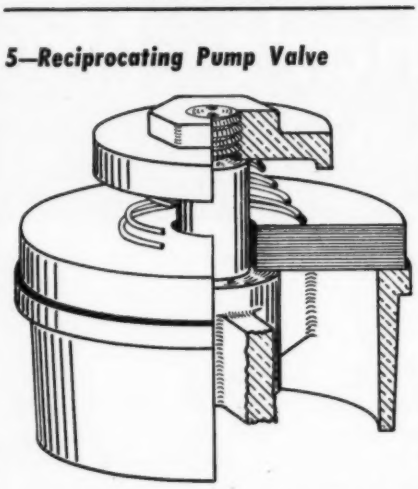
What's New!

5—Reciprocating Pump Valve



Designed for reciprocating pumps in pipe line and refinery service, the new American Industrial Pump Valves and seats are furnished in bronze alloy with a special phenolic resin valve plate for operating temperatures up to 300° F. and pressures up to 750 psi. For temperatures up to 950° F., the same design is available in stainless steel. In the three-web seat, the center guide post is cast as an integral part of the alloy seat, thus eliminating a threaded connection, which often corrodes and breaks. The plastic valve plate's life can be doubled by reversing it when one side becomes worn excessively. The conical valve spring, especially designed to offer resistance of only four lbs., will compress to a height of ⅛ in., with no coil clash to cause fatigue, permitting a greater valve life in all pumps. The simple, threaded valve and spring retainer is recessed to prevent damage to the spring when valve is fully opened. The hexagon crown design of this retainer facilitates changing valve plates without removing the seat from the pump. American Iron & Machine Works Co.

6—Silicone Rubber Parts

Molded, extruded, punched, and lathe-cut rubber parts fabricated from the new Stalwart No. 250 Silicone rubber stock are now available. The material is said to feature a marked improvement over previous Silicone rubbers in tensile strength, elongation, tear resistance, and dielectric properties. It is recommended for applications requiring good mechanical strength and resilience at temperatures below —50° and above 200° F. Parts fabricated from it will give satisfactory service at temperatures below —100 and above 500° F. Parts are resistant to ozone, tricesyl phosphate, and chlorinated hydrocarbons. Stalwart Rubber Co.

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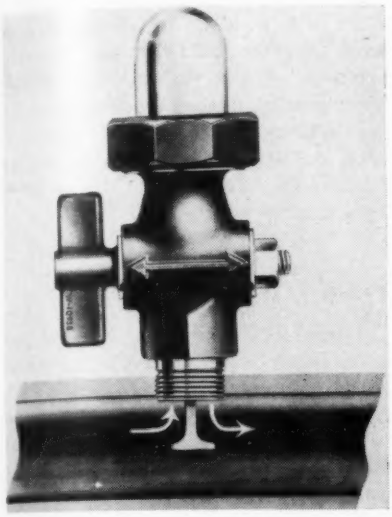
What's New!

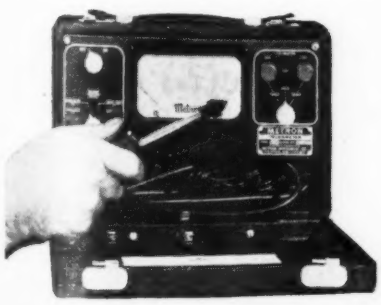
7—Sight Glass with Valve



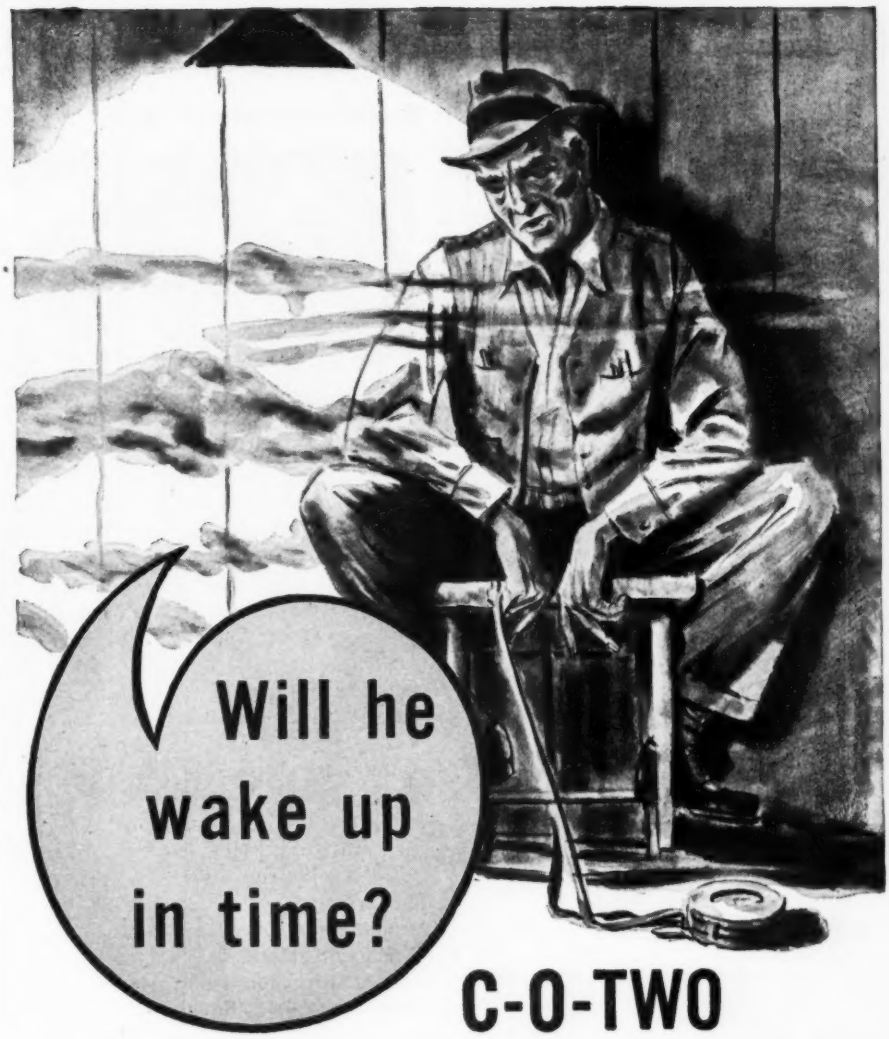
The Worthington Valve-type Sight Glass allows the clarity or turbidity of transparent liquids flowing under pressure through pipe lines to be observed. As indicated in the illustration, a differential pressure is established across the deflector to allow some of the liquid to circulate continuously through the glass observation bowl. The valve is so constructed that the observation bowl may be removed for cleaning, while the line is in service. Worthington Pump & Machinery Corp.

8—Motor Tachometer

Recently added to the "Metron 48" series tachometers is the new type 48K with ranges especially suited for motor and generator testing. Total speed range without adapters is 360 to 4000 rpm., accommodating all synchronous or induction motors and most geared type motors. Head adapters are available for checking high speed universal motors or extreme low speed gear motors. Any one of ten ranges is instantly selected by a rotary switch. No damage results from overspeeding up to about 8000 rpm. regardless of range setting. Metron Instrument Co.



More "What's New!" Items, p. 924



C-O-TWO

is a 24 hour a day automatic fire watchman

We're all human . . . we all slip up now and then. One of these slips can cost you your business . . . especially at night when a little fire could be unnoticed for hours.

Round-the-clock automatic fire protection is the modern way to keep your business firesafe. The C-O-TWO Combination Smoke Detecting and Fire Extinguishing System is wide awake and on the job constantly. The first whiff of smoke in a protected area sounds an alarm. Then fast, clean, non-damaging carbon dioxide blankets the fire, putting it out in seconds, before it spreads and causes extensive damage.

C-O-TWO manufactures and installs fire protection systems for one, two, twenty-four, sixty or any number of enclosed or semi-enclosed spaces. Let an expert C-O-TWO Fire Protection Engineer help you plan modern, dependable, fully approved fire protection for your property now, before fire strikes. Remember . . . tomorrow may be too late. Write us today for complete information.

C-O-TWO

C-O-TWO FIRE EQUIPMENT COMPANY
NEWARK 1 • NEW JERSEY
Sales and Service in the Principal Cities of United States and Canada
AFFILIATED WITH PYRENE MANUFACTURING COMPANY

Buffalo TANKS

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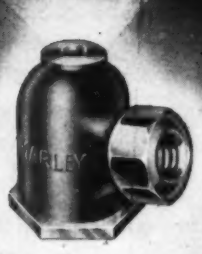
Specify
MARLEY
NOZZLES



For Dependable Service
Marley patented Spray NOZZLES are used by industries where efficiency and economy are required.

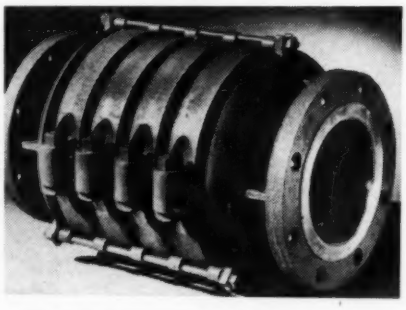
Write today for your Copy of the Marley Spray Nozzle Bulletins.

MARLEY NOZZLES

THE MARLEY CO., INC.
KANSAS CITY 15, KANSAS

What's New!

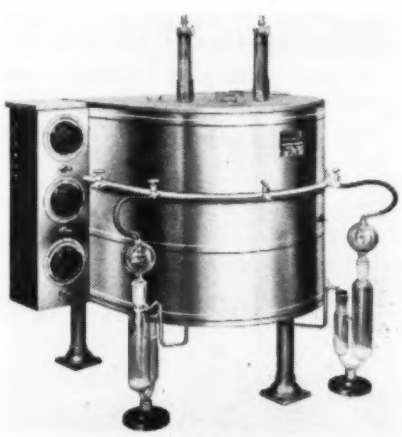
9—Packless Expansion Joint



The Adsco "Corruflex" Packless Expansion Joint requires no packing and is said to be suited for use in remote and difficult-to-service locations. Economical installations are possible since the compactness of the new joint permits its use in trenches, tunnels, or other cramped quarters. It is available in sizes from 3 to 24-in., single or multiple corrugation, with or without self-equalizing rings, single or double units, and with either flanged or welding ends. It is supplied in copper, stainless steel or other alloys, and with internal sleeves if required. The traverse of the Corruflex Joint ranges from fractions of an inch to 15 in., and it will operate under pressures from vacuum to 300 psi., and temperatures from sub-zero to 1600° F. American District Steam Co.

10—Sulfur Apparatus

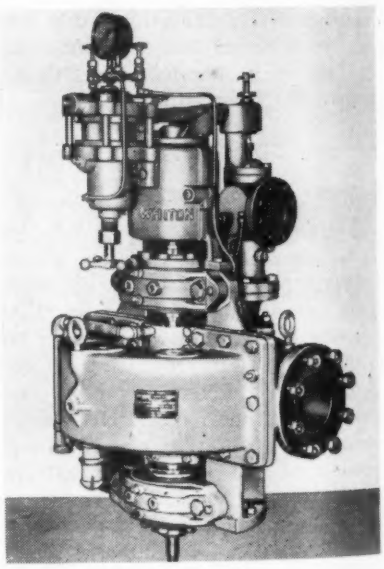
The Vertical Tube Sulfur Determination Apparatus was engineered to provide a rapid method for multiple analysis of substances encountered in the petroleum and organic chemical industries. Pyrex tubes are replaced by stainless steel. Each of the six vertical tubes is heated by a "Ful-Kontrol" heater which has a maximum temperature range of 1525° F. Precise control of heat from 0 to 320 watts is obtained with built-in auto-transformers. Nickel chromium elements embedded in special refractories are protected by a steel tube jacket. Insulation of glass wool separates all tubes and the outer surfaces of the instrument. Tubing for connection to a vacuum line has six outlets with shut-off valves at each outlet. Overall dimensions are 22 in. long, 24 in. high, 36 in. wide. Precision Scientific Co.



11—High Strength Fire Hose

"Matchless Carbolized Fire Hose" is a new high strength fire hose with high resistance to acids, acid fumes, oil and gasoline. Manufacturer states hose is designed primarily for fire protection and general wash-down service in oil refineries and acid plants. It is constructed with a natural rubber tube, two plies of chemically-treated cotton cord fabric, and a neoprene cover. It is built to resist 400 psi. test pressure, and is marketed in white or black. United States Rubber Co.

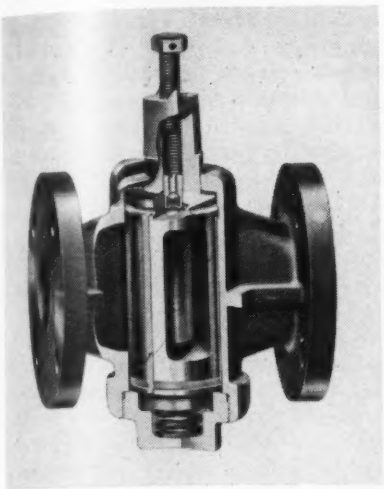
12—Vertical Steam Turbine



A small, compact vertical steam turbine to drive centrifugal pumps or other vertical units now is available which can develop ratings up to 90 bhp. The turbine is made in either semi-steel or cast steel to meet practically any steam pressure and temperature requirements. The standard model can take thrust loads in either direction up to about 1500 lbs., or can be changed to take higher thrust loads if desired. Equipment includes constant speed and emergency governors, and a bolting flange at the lower part of the casing to permit fastening to the driven unit. Whiton Machine Co.

What's New!

13—Self-sealing Plug Valve



Longer leakless service, because it automatically compensates for wear, is claimed for the new Homestead-Reiser "Self-Seald" Valve, a lubricated plug valve. The cylindrical plug has a wedge action which not only adjusts itself for wear, but also keeps the sealing surfaces of the plug and body in intimate contact at all times to provide an extra tight seal against leakage, and lower lubricant losses, the manufacturer states.

14—Dry Chemical Extinguisher

The new C-O-Two Dry Chemical Type Fire Extinguisher is said to be foolproof and easy to use. Company states the device has no siphon tubes or valves within the cylinder to become clogged or inoperative. Unit has a dry chemical, especially formulated to ensure proper flow. Discharge nozzle and hose remain empty until extinguisher is actuated. Two sizes are available—20 and 30 lb. capacity. C-O-Two Fire Equipment Co.

More "What's New!" Items, p. 926

ACCURATE GAUGING

SAFE STORAGE for *Pressure* Products

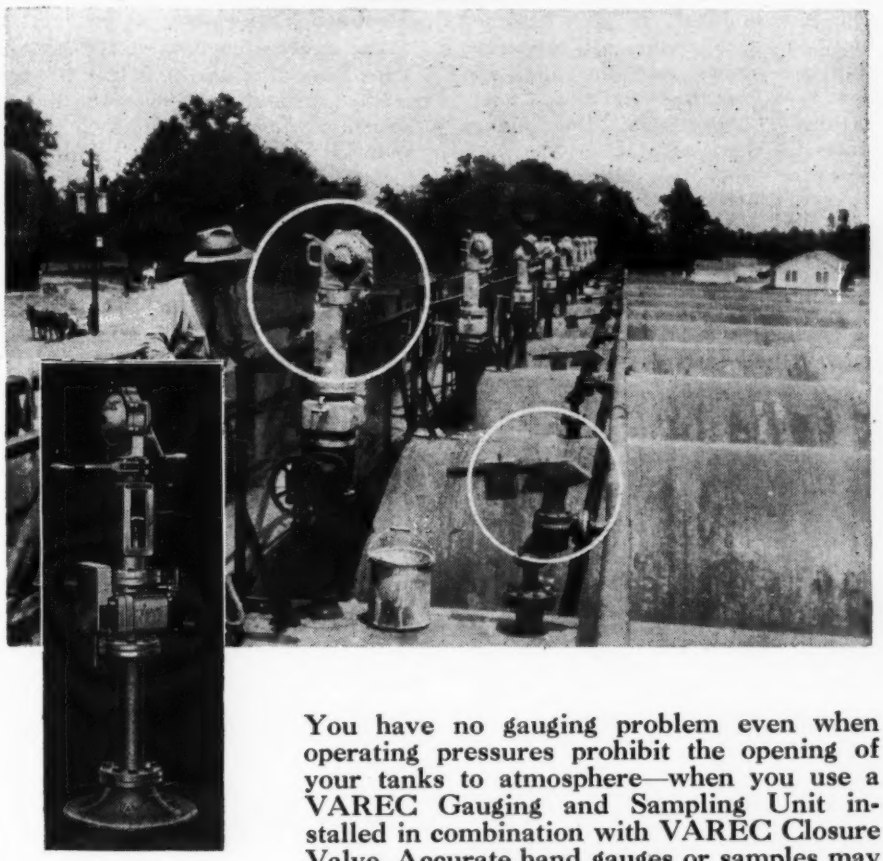


Figure No. 410 "VAREC" Gas-tight Gauging and Sampling Unit with portable head, and Figure No. 278 "VAREC" Closure Valve.

You have no gauging problem even when operating pressures prohibit the opening of your tanks to atmosphere—when you use a VAREC Gauging and Sampling Unit installed in combination with VAREC Closure Valve. Accurate hand gauges or samples may be taken without depressuring your tanks.

Protection too, against excessive pressure from sudden temperature changes—a reliable "VAREC" Pressure and Vacuum Relief Valve is made to meet your storage requirements.

Write today for engineering data on "VAREC" pressure product storage equipment.

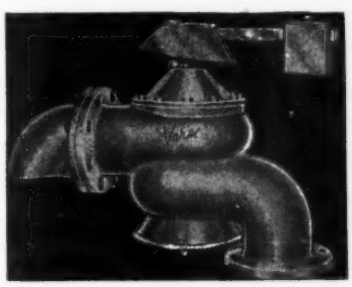


Figure No. 480 Series "VAREC" Pressure and Vacuum Relief Valve, dead weight loaded pallet. Available in sizes from 2 in. to 8 in. and pressure settings to 1 lb. 8 oz. Pressure settings to 60 lbs. available in spring-loaded pressure pallet type, Figure No. 481 Series.

CP-10

PROVED and APPROVED "Varec"

THE VAPOR RECOVERY SYSTEMS COMPANY
COMPTON, CALIFORNIA, U.S.A.
NEW YORK 30 CHURCH ST. PITTSBURGH 939 GULF BLDG. CHICAGO 122 SO. MICHIGAN AVE.
TULSA 409 TULOMA BLDG. HOUSTON 821A M.&M. BLDG.
CABLE ADDRESS: VAREC COMPTON (ALL CODES)

15—Safe Floor Cleaner

The new Model "MC-EX" explosion-proof floor machine for automatic scrubbing, cleaning, and polishing in hazardous areas has been put into volume production, according to the manufacturer. It was designed for floor maintenance in refineries, chemical plants, and the like, and has been certified by the Underwriters' Laboratories, the maker states. A dual AC 110 or 220 volt, capacitor induction type General Electric motor is 1/3 hp. for the 14-in. diameter machine and ¾ hp. for the 16-in. machine. Power cord is a three-conductor type with a ground jack. Multi-Clean Products, Inc.

16—Gage Illuminators

The new Jerguson Solid-Wedge Type Gage Illuminator is said to give evenly diffused light over the entire length of gage glass with no glare spots or blind areas. The Illuminator incorporates the principle of solid-wedge lighting in combination with plastic, whereby the illumination from a single light source is reflected from an angular surface and flows with evenly diffused intensity through the transparent gage glass. Units are made in both explosion-proof and standard models for all sizes of gages. They are also made in both single and double section styles. Lighting is by a standard small bulb, offering savings in electricity. Only one bulb is needed to illuminate two gage sections with double section illuminator. Jerguson Gage & Valve Co.

CUT AND FILE THESE TWO HANDY REFERENCE LISTINGS.
FOR MORE COMPLETE INFORMATION, REQUEST A CATALOG.

Precision SAYBOLT VISCOSIMETER

This new, constant temperature, trouble-free Viscosimeter of 2 or 4-tube capacity, is for use according to A.S.T.M. Method D-88. Entirely self-contained, it is built for continuous duty and is safe from fire hazard. Combining a new measure of ease, consistent accuracy, and absolute dependability, this Viscosimeter will aid the operator by releasing his attention from "mechanics" and will promote both speed and accuracy.

Bulletin 705A contains complete information. Get your copy today.

Precision Scientific Co.

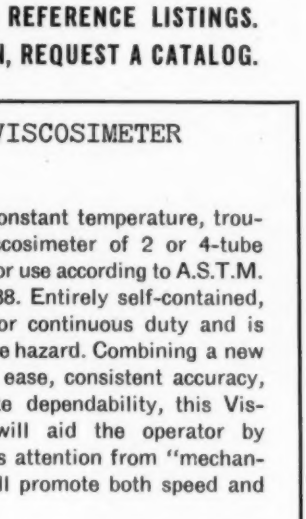
Precision MODEL S KINEMATIC VISCOSITY BATH

This Viscosity Bath is for Kinematic Viscosity determination with Ostwald, Ubbelohde, or other suspended level viscometers commonly used in A.S.T.M. Method D-445 or A.A.F. Specification 3608.

- 6-Tube Capacity.
- Temperature range from 70°F. to 212°F.
- Sensitivity ±0.25°F.
- Octo-Mix Tubular Stirrer.

For the complete story on this Viscosity Bath ask for Catalog 705A1.

Precision Scientific Company



Precision Scientific Company
3737 W. CORTLAND ST. . . CHICAGO 47, ILL. U.S.A.
Scientific Research & Production Control Apparatus
OFFICES IN CHICAGO, NEW YORK, PHILADELPHIA AND SAN FRANCISCO

Trade Literature

17—Heat Exchangers

Plate Fabrication and Heat Exchangers; a 16-page booklet listing general facilities, manufacturing equipment, welding procedure qualifications, and giving standard construction details for heat exchangers; with sections devoted to typical plate fabrication and heat exchanger examples. Downingtown Iron Works, Inc.

18—Instrument Prices

Wheelco Bulletin AC-1 and *Price Lists* covers latest effective prices on line of AC and DC voltmeters, milliameters, and ammeters; and DC millivoltmeters and microammeters. Wheelco Instruments Co.

19—Industrial Fire Hose

B. F. Goodrich Industrial Fire Hose, Bulletin 3740; details the methods and materials with which the hose is constructed, and gives data on size, couplings, and test pressures, and weight coupled and uncoupled for 50-ft. lengths. B. F. Goodrich Co.

20—Electronic Instruments

Dynalog Electronic Instruments, Bulletin 427: 32 pages of technical details, drawings showing operating circuits, and complete information on a line of indicators, recorders, and controllers of the electrical bridge, self-balancing type designed principally for measuring resistance; includes all latest models. Foxboro Co.

21—Self-priming Centrifugals

Marlow Self-Priming Centrifugal Pumps, Bulletin IB49: 12-page booklet on a line in sizes from 1½ to 10 in., 15 to 3500 gpm. capacity; electric-powered, long and close coupled, vertical and belt-driven; handling liquids with viscosities up to 500 SSU.; includes tables for determining friction loss in pipe and fittings and for obtaining maximum practical dynamic suction lifts. Marlow Pumps.

22—Pre-insulated Piping

Ric-wiL Insulated Piping Systems Catalog, Section 480-4: 28 pages on pre-fabricated, pre-insulated, and pre-sealed piping units, tees, ells, and the like, for either overhead or underground installations; including instructions for field connections, typical specifications, packing and shipping information. The Ric-wiL Co.

23—Laboratory Heating Jackets

Gyco Heating Jackets with Safety Thermostats; a 12-page booklet including for the first time full information on the use of the safety thermostats on laboratory heating jackets for flasks, tubes, beakers, jars, Buchner and other type funnels, desiccators, and bottles. Scientific Glass Apparatus Co., Inc.

24—Control Instruments

Cono-Controls, Bulletin 103: a six-page booklet giving brief specifications and descriptions on principal items in a line of control instruments including control valves, piston-operated and butterfly; loading regulators, instrument supply regulators, pressure transmitters, pneumatic thrustmeters, etc. Conoflow Corp.

25—Caustic Dilution

Continuous, Automatic Caustic Dilution, Standard Method 129: an eight-page bulletin, with charts, graphs, tables, and a flow diagram describing the use of a proportioning pumping system for handling economically the dilution to plant needs of concentrated caustic soda with an accuracy to within ±1½% at all flows within the range of the equipment. Proportioneers, Inc.

26—Bronze Valves

Kennedy Bronze Globe and Angle Valves, Circular 101; a pocket size folder giving important construction features of valves for services up to 150 psi. steam, or 300 psi. cold water, oil, air, or gas; including a table of available sizes and dimensions. Kennedy Valve Co.

27—Valve Actuators

Hydraulic Actuating Cylinders for Valves, Bulletin 453, presents dimensions, capacities, weights, applications, and other engineering data on heavy duty cylinders for use in actuating refinery gate valves of large sizes. Ledeen Manufacturing Co.

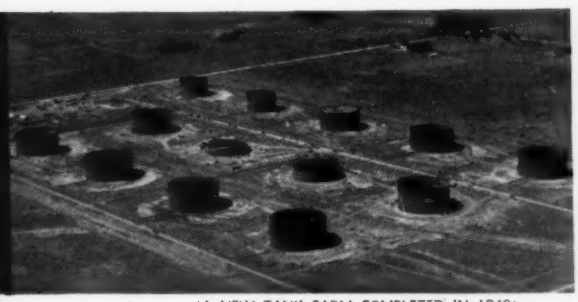
28—Strainers

Elliott Twin Strainers, Bulletin A-13: 12 pages with detailed drawings, dimensions, specifications, pressure drop graphs, etc. on a line of dual strainers of up to 500 psi. WP., and up to 10-in. sizes. Elliott Co.

More "What's New!" Items, p. 928

NATASCO NATASCO NATASCO

A MILLION DOLLAR INVESTMENT PROTECTED WITH



(A NEW TANK FARM COMPLETED IN 1948)

NATASCO NATASCO NATASCO NATASCO NATASCO NATASCO NATASCO NATASCO NATASCO NATASCO NATASCO NATASCO NATASCO

The owner of this tank farm knows the value of Natasco products and service. The proper Natasco coatings were selected and then applied to the interior of these tanks by experienced Natasco workmen to provide the maximum protection from corrosion. Whether your tanks are just being erected or have been in service for years, Natasco protection will make them last many years longer at a reasonable cost and is *backed by the Natasco Guarantee.*

Why Natasco Products give longer life to tanks

1. They are insoluble in petroleum and petroleum vapors.
2. They are chemically inert in dilute solution of sulphuric and hydrochloric acids.
3. They are chemically inert to hydrogen sulphide.
4. They are impervious to gases.
5. They have high dielectric strength.
6. They are elastic, withstanding the stresses of expansion, contraction, and bending of metal without rupture.
7. They have adequate film thickness.
8. They adhere to metal, wood or cement.

Let Natasco's years of experience be your guide in proper tank protection. Telephone, call or write for complete information.

"KEEPS NEW TANKS NEW... MAKES OLD ONES DO..."

PROTECTS TANKS AGAINST CORROSION

THE Natasco COMPANY

TULSA, OKLAHOMA

Lease Tank Service—West Texas Area: Williams Construction Company, Odessa, Texas

California Representative: Coast Contractors, Ltd., 4636 E. Slauson, Maywood, Cal.

29—Liquid Level Gages

Penberthy Liquid Level and Water Gages, Catalog 35: a 72-page catalog on the complete line of this equipment as used in the petroleum chemical, and power industries. Penberthy Injector Co.

30—Slurry Pumps

Pacific Centrifugal Slurry Pumps, Bulletin 86-A: detailed construction drawings on both the single and the double suction type slurry pumps with capacities from 20 to 3000 gpm., at temperatures to 800° F., and heads of 150 to 600 ft. Pacific Pumps, Inc., a Dresser Industry.

31—High Vacuum Equipment

High Vacuum Apparatus, Bulletin 10A: 48 pages, revised booklet on this type of equipment, including information on the new "Pressovac" Pump for pumping to 25 microns and the "Cenco-Hypervac 23" Pump, a unit for pressures to 5 microns on mercury. Central Scientific Co.

32—Side-entering Agitators

IPE Side-Entering Agitators, Bulletin 482: four pages of specifications, drawings, and a general description of a line of mixing equipment, including one model in which stuffing box can be repacked without emptying or depressurizing the tank in which it is installed. Industrial Process Engineers.

33—High-temperature Plastic

"Kel-F" Data, Technical Bulletins 1-1-49, 2-1-49, and 3-1-49 cover physical and mechanical properties, and specific thermal treatment for a new plastic—a polymer of trifluoroschloroethylene—which stands up under temperatures from −320 to+390° F. M. W. Kellogg Co.

34—Turbine Agitators

Mixco Heavy Duty Turbine Agitators, Catalog B-89: specifications, cutaway views, and other details on mixing units, available as a standard package for top or bottom entry in open or closed tanks. Mixing Equipment Co., Inc.

35—Metallizing Material

Colmonoy Sprayweld Wire, May, 1949; a 7-page booklet containing latest data on this product, a hard-facing wire designed for use in standard metallizing guns; includes application instructions, surface preparation, spraying, cooling and finishing, also proper gun settings. Wall Colmonoy Corp.

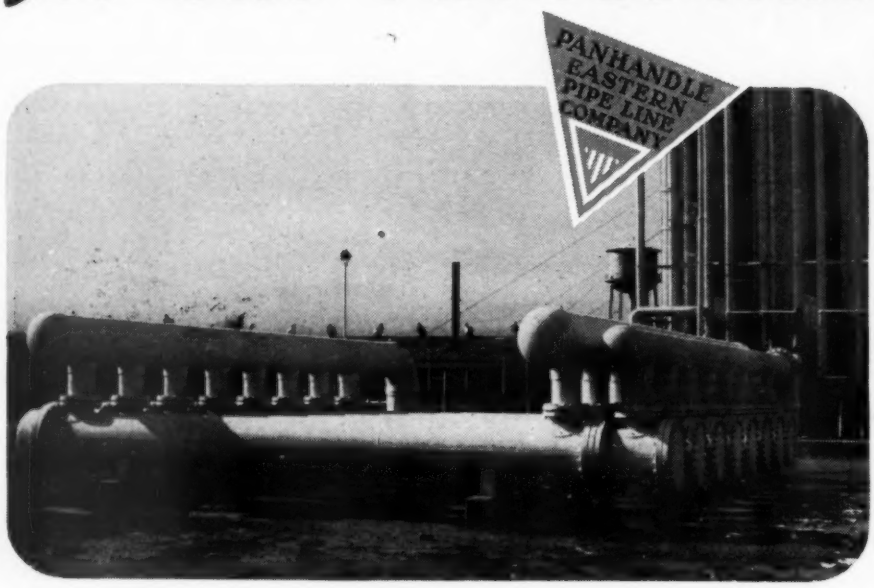
36—Organic Intermediate

Koppers Technical Bulletin C-9-130: 24 pages covering physical and chemical properties, uses, and reactions of a liquid alkylated phenol, mono-tert-butyl-metal-cresol — "MBMC" — useful in compounding germicides, rubber chemicals, lube oil additives, perfumes, and synthetic resins. Koppers Co., Inc.

For Your Convenience

Business reply cards are included in this issue of PETROLEUM PROCESSING to assist you in obtaining more information on any items reviewed in "What's New!" You'll find them facing page 921. Just circle the numbers corresponding to the numbers on the items you're interested in, fill in the bottom of the card, and drop it in the mail. No postage required.

For GAS PROCESSING

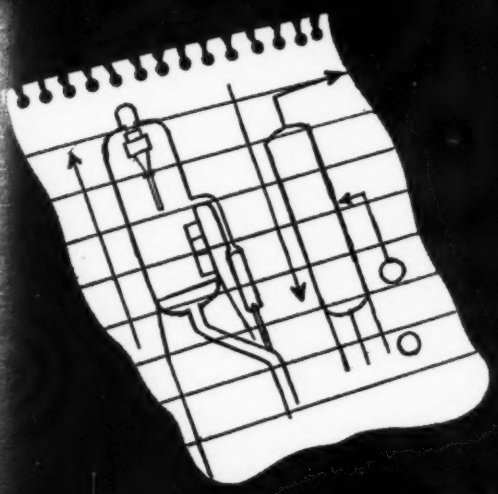


PANHANDLE EASTERN PIPE LINE COMPANY

Western Heat Exchangers installed at Panhandle Eastern's dehydration plant at Liberal, Kansas are indicative of Western's versatility in Engineering, design and manufacturing facilities for all phases of gas processing and transmission. Close attention to vital engineering specifications from design to installation is assured in the manufacture of all Western equipment for gasoline plants, refineries, chemical processing plants and pipe lines throughout the world.

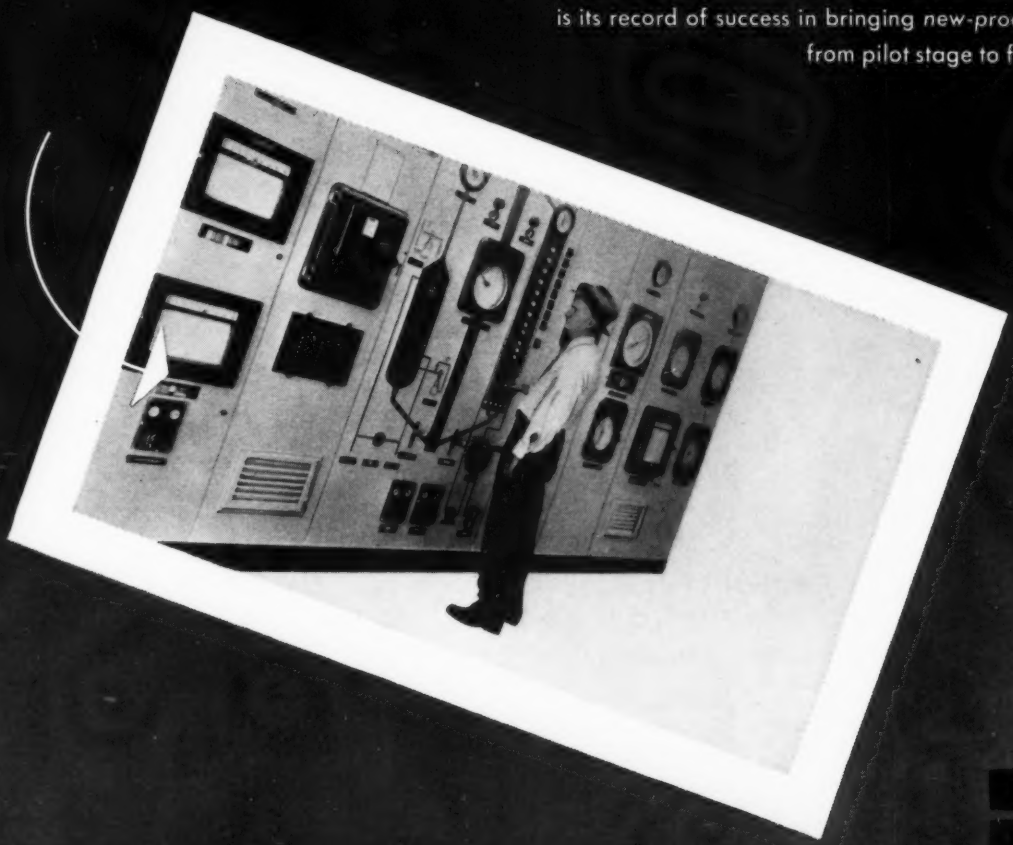
WESTERN
HEAT EXCHANGERS
Manufactured by
WESTERN SUPPLY COMPANY
P.O. BOX 1888 TULSA, OKLAHOMA
SALES OFFICES — DALLAS — HOUSTON

See Western's catalog pages in the current issues of Chemical Engineering Catalog, Refinery Catalog and Thomas Register.



FULFILLMENT

Fulfillment of contractual guarantees in plant design and construction is to be expected of any well qualified organization. It becomes a basis for preference as engineering commitments are consistently surpassed. Lummus stands ready for evaluation on whatever scale of values means the most to you: output, completion dates, or long initial runs. But the test that Lummus regards as the best evidence of its ability to fulfill your needs is its record of success in bringing *new-process* plants from pilot stage to full-scale operation.



teamwork
economy
perspective
resourcefulness

LUMMUS designs and builds with **FULFILLMENT**
technique

FULFILLMENT (plant capacity)

A catalytic cracking plant, designed for 5400 B/D, was boosted to 6000 B/D on the 85th day of its initial run. Guaranteed percentage yield of high octane gasoline was also exceeded: 3070 B/D of 10-lb. RVP gasoline against a 2040 B/D guarantee.

FULFILLMENT (initial run)

A long initial run accurately forecasts long-term performance almost every time. This 10,000 B/D catalytic cracking plant was first shut down (for inspection) after 240 days on stream. No major maintenance was necessary. Total turnaround time was some 10,000 manhours.

FULFILLMENT (continuous output)

A continuous processing record for this customer—over 1,200,000 barrels of crude—was established by this Lummus high-pressure cracking unit—on the line for 124 days.

FULFILLMENT (completion schedule)

A polyform gas reversion plant, designed to produce 4000 B/D of high octane gasoline, was completed on a tight 10-month schedule. The acceptance test run met all guarantees. The initial run continued 65 days before shutdown for employee-training purposes.

THE LUMMUS COMPANY
420 Lexington Avenue, New York 17, N. Y.

LUMMUS

CHICAGO—600 South Michigan Avenue, Chicago 5, Ill.
HOUSTON—Mellie Esperson Bldg., Houston 2, Texas

The Lummus Company, Ltd., 525 Oxford St., London, W-1, England

Société Française des Techniques Lummus
39 Rue Cambon, Paris 1er, France

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Esquina Las Gradillas, Caracas, Venezuela

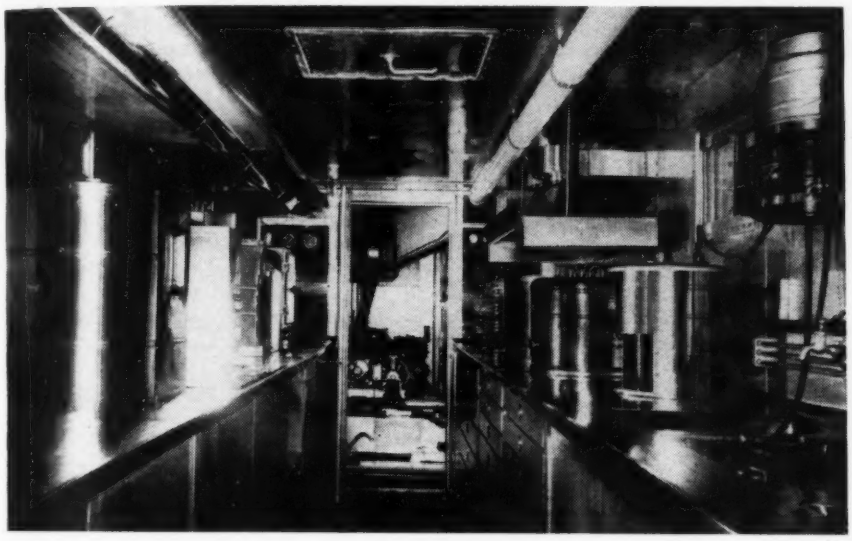
NATIONAL ASSOCIATION OF OIL STEEL CHEMICAL CONSTRUCTORS

NEWS OF

Manufacturers—Suppliers—Engineering Firms

Serving the Petroleum Processing Industry

Precision Scientific Builds Mobile Laboratory for Quartermaster Corps



Interior view of mobile laboratory, showing standard testing apparatus in foreground and air-conditioning equipment through door at rear

A complete, mobile petroleum laboratory, built on a four-wheel trailer truck body and lightweight enough to be carried by air, has been made by Precision Scientific Co. of Chicago, following plans and specifications prepared by the U. S. Army Quartermaster Corps.

Self-contained and independent of outside sources for electrical power, heat control, etc., the laboratory is equipped to test all grades of gasoline, fuel oil, lube oils, and greases. The first pilot model has been turned over to the Corps by Precision Scientific. Four additional units are to be built later following field tests of the present model.

Weighing 11,000 lbs. fully loaded, it is contained in a body 25 ft. long, 8 ft. wide, and 7 ft. 10 in. high. An integral jacking device raises the body to the level of a transport plane floor and drops the wheel carriages for loading it onto a plane. The unit can be towed by a jeep although ordinarily it would be drawn by a 2½ ton truck. Inside temperature can be maintained at 70° F. while outside temperatures are as low as 70 below.

American Cy Renews Scholarships

American Cyanamid Co. has announced the renewal of 15 scholarships for the year 1949-50, chiefly in the fields of chemistry and chemical engineering. The scholarships, which generally provide $1500, are at Brown University, MIT, Columbia, Princeton, Pennsylvania State College, Cornell, Purdue, and the Universities of Virginia, Illinois, Notre Dame, Michigan, Wisconsin, Minnesota and Colorado.

Grinnell Has Film on Oil Fires

"Emulsion Extinguishment of Oil Fires with Water Sprays" is the title of a 16 mm. sound color film now available from the Grinnell Co., Inc., Providence, R. I. The film, which runs for 20 minutes, presents a complete summary of the results of 15 years experience in extinguishing oil fires with water. It is available for free showing before groups having 16 mm. sound projectors, and arrangements may be made by writing to General Sales Manager's Office, Attention: K. P. Jones, Grinnell Co., 227 W. Exchange St., Providence 1.

Columbia Chemical To Make Organics

Columbia Chemical Div. of Pittsburgh Plate Glass Co. has made its initial entry into the field of organic chemical compound production by placing in operation recently its new million-dollar plant adjoining the large chlorine and caustic soda facilities at Natrium, W. Va. The new plant will produce monochlorbenzene, muriatic acid, paradichlorbenzene, and orthodichlorbenzene as co-products in a continuous process, somewhat similar to oil processing. Supplies of the major raw material, benzene, will be taken from the coking ovens of Wheeling and Pittsburgh steel mills.

Blaw-Knox Opens in Tulsa

Chemical Plants Division of Blaw-Knox Co. last month announced the expansion of its oil and gas department through additional personnel and the opening of a district office at Tulsa. The new office, under the supervision of R. H. Hazlett, manager of the department, will provide sales and engineering services to the oil and gas industries of the Southwest, and will also be available for service on chemical plant projects.

Charles B. Barry, of Tulsa, has been appointed chief engineer for the oil and gas department, and will have headquarters in the new district office. Mr. Barry previously was with Jones & Laughlin Supply Co. as process engineer, and prior

Mr. Barry

Mr. Baird

to that was with Phillips Petroleum Co. Carl E. Baird, originally of Dallas, has been appointed sales representative for the Tulsa office. Prior to joining Blaw-Knox in 1946, Mr. Baird was in the Bureau of Mines' synthetic liquid fuels division, and with Pittsburgh Equitable Meter Co. and Merco Nordstrom Valve Co.

Brown Instrument Courses Begin

A comprehensive 13-week course and two five-week courses have been scheduled for the period, Aug. 15 to December 2, by the Brown Training School of Industrial Instrumentation, Brown Instruments Div. of Minneapolis-Honeywell, Philadelphia.

Devoted to maintenance and repair, the courses will cover millivolt-

meter type pyrometers, mechanical potentiometer pyrometers, continuous balance electronic type potentiometers, electrically-operated automatic control, flow meters, thermometers, pressure gages, hygrometers, air-operated automatic control, tachometers, resistance thermometers, CO_2 and analygraph.

The recent addition and opening of a new factory to the main plant in Philadelphia enables the training school to move to the plant annex, where it will occupy double the facilities previously available.

Lukens Observes Anniversary

The 139th anniversary of the continuing production of iron and steel plate at its original location in Coatesville, Pa., was observed July 2 by Lukens Steel Co. The company, since its founding in 1910, has been under an uninterrupted line of family ownership and management.

GATX Exhibits at Railroad Fair

General American Transportation Co. will be represented at the Chicago Railroad Fair this year by a two-fold exhibit which includes the latest all-welded, aluminum tank car. Also featured will be the firm's liquid storage terminals, and the fabrication of heavy equipment used in the refining and process industries, as well as the design and building of Wiggins floating roofs, gasholders, and other structures for the conservation of volatile vapors.

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Eggelhof Engineers Meet in Houston

The entire sales force from the eight offices of Eggelhof Engineers met in Houston June 16-19 for a three-day sales meeting, part of an educational program involving semi-annual meetings with the engineering and sales personnel of the manufacturers represented by Eggelhof Engineers. The chief engineers of Cuno Engineering Corp., C. H. Wheeler Mfg. Co., and Todd Combustion Equipment Div. were present to review technical details and application of their equipment.

Peerless Pump Personnel Changes

In recent personnel changes in the sales department of Peerless Pump Div. of Food Machinery and Chemical Corp.: Frank W. McCann, previously head of centrifugal pump sales at the Indianapolis Works, has been appointed manager of the firm's Atlantic district sales. He will headquarter at 37 Wall St., New York City, and will cover all New England and Middle Atlantic states.

Mr. McCann

Mr. Hull

Robert H. Hull replaces McCann at Indianapolis. He was located previously at the Los Angeles Works in charge of sectional sales of the Peerless vertical pump line. His new duties will include both vertical and horizontal type centrifugal pumps.

Acid-proofing Firm Reorganizes

The Electro-Chemical Supply and Engineering Co. of Paoli, Pa., in the acid and corrosion-proofing field since its founding in 1912, has announced a reorganization of key personnel and the completion of a new plant at Emmaus, Pa., near Allentown. Officers are Dr. C. R. Payne, president; J. W. Grant, vice president and sales manager; Wm. A.

Sesher, treasurer and production manager; Walter L. Sheppard, Jr., advertising manager and export sales manager.

Davison Moves into New Home

General offices and headquarters of the Davison Chemical Corp. have been moved into the newly-renovated Davison Chemical Building—Charles and Fayette Sts., Baltimore 1, Md. The new home, a 12-story structure erected in 1898, was purchased by Davison over three years ago, but occupancy was delayed because of the shortage of materials necessary to its rehabilitation. The company occupies the entire seventh—twelth floors.

Branches, Distributors

Tempil° Corp. announces that **Metal & Thermit Corp.,** 120 Broadway, New York 5, has added Tempil° temperature-indicating products to the lines of welding accessories distributed by them.

Bigelow - Liptak Corp., Detroit, manufacturer of industrial furnace enclosures, has selected the **Stapp Engineering Co.,** 513 Tabor Building, Denver, as its representative in Colorado, Wyoming, New Mexico and portions of Nebraska, S. Dakota and Texas.

Hewitt-Robins, Inc., Buffalo, N. Y., has appointed **Hines Bearings and Industrial Supply Co.** of Billings, Mont., as distributor of Hewitt industrial rubber products in Billings and the surrounding territory.

Weston Electrical Instrument Corp., of Newark, and its subsidiary, **C. J. Tagliabue Corp.,** have established a district sales office at 6230 3rd St., N. W. Washington, D. C., with Lawrence F. Parachini as district manager.

Black, Sivalls & Bryson, Inc., has announced the addition of Snyder, Texas, to their list of stocking points for field-welded steel storage tanks, and oil and gas separators, with William A. Watkins in charge of sales.

Mixing Equipment Co., Inc., Rochester, N. Y., has named the Industrial Sales & Engineering Co. of Buffalo as a field representative. The firm is headed by Roy A. Bass, formerly with Ross Heater & Manufacturing Co. and Dresser Industries, Inc.

Other Personnel

Bigelow-Liptak Corp.—William T. Macdonald has been appointed sales representative in northern Ohio, and Kenneth Gregory sales representative in Michigan. They will headquarter in Cleveland and Detroit, respectively.

Gimpel Machine Works—Martin P. Teller is new vice-president in charge of engineering with Gimpel in Philadelphia. Previously he was Valve Engineer with **Schutte & Koerting Co.**

Arcos Corp.—C. T. Posey has been appointed field engineer in the Midwestern area with headquarters at 1324 Fulton St., Chicago 7, to assist Arcos distributors in that area in their stainless steel electrode sales activities.

Republic Flow Meters Co.—James D. Cunningham, president, is the 1950 nominee for president of the American Society of Mechanical Engineers.

A. P. Green Fire Brick Co.—William S. Lowe, of Winsted, Conn., has been elected to fill the position of Executive Vice-President. He comes to the A. P. Green Co. from the

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News of Suppliers

Reeves-Ely Laboratories, Inc., New York, with which he has been associated since 1944.

Hooker Electrochemical Co.—Allen L. Spafford has been appointed field salesman in upper New York State and western Pennsylvania, with headquarters in Hooker's Niagara Falls office.

Black, Sivalls & Bryson, Inc.—W. W. (Woody) Pyeatt has rejoined the company and will direct the New Orleans sales offices.

Cooper Alloy Foundry Co.—Harry A. Cooper, president, was elected president of the Alloy Castings Institute during its recent annual meeting in Colorado Springs, Colo. Mr. Cooper is well-known throughout industry for his pioneering work in the development and growth of the stainless steel industry.

Lincoln Electric Co.—E. E. Goehringer has assumed sales and engineering responsibility in the Indianapolis area as district manager. Omer Blodgett has been transferred to Lincoln's Chicago office as sales engineer. R. L. Hall and Robert Hirsch have been assigned to the Pittsburgh office as district engineers.

American Brake Shoe Co.—Edward R. Anderson has been appointed vice-president of the company's Kellogg Division, manufacturers of air compressors and paint spraying equipment. He will be located in San Francisco.

Graver Tank & Mfg. Co.—Engel E. Devendorf has been appointed export manager for both Graver and the **Phoenix Manufacturing Co.** He will handle the foreign phases of sales, advertising and promotion, and export for all divisions of both Graver and Phoenix.

Reliance Electric & Engineering Co.—William H. (Red) Compton, for the past four years manager of Reliance's Rockford, Ill. sales office, has been made supervisor of standard motor sales with headquarters in Cleveland.

Walsh Refractories Corp.—James L. Crawford, formerly vice president and general manager, has been promoted to the presidency. N. S. C. Walsh, retiring president, was named honorary Board Chairman.

Mathieson Chemical Corp. — With the retirement of E. E. Routh, vice president, director of sales; D. W. Drummond has been named vice president, director of industrial chemicals sales, and S. L. Nevins has been named vice president, director of agricultural chemical sales.

Gasoline and Cycling Plant Operation

Conducted by DAVE THORNTON

The Questions and Answers presented here are from a wire recording of the popular "Information Please Session" of the 28th Annual Convention of the Natural Gasoline Assn. of America, in Fort Worth, April 20-22. Their publication is made possible through the co-operation of the various authorities participating, W. F. Lowe, NGAA Secretary, and J. E. Pew, Sun Oil Co., session moderator.

In your opinion what will be the attitude of the Texas Railroad Commission on flaring of LP-Gases from plants when such products cannot be sold?

Frankly I do not think the Commission yet has a definite plan of coercive action in mind. We are concerned about the flaring of LPG and consider it a waste of valuable petroleum hydrocarbons, just as we are opposed to the flaring of natural gas and the underground loss of crude oil.

We recognize that extreme seasonal fluctuations in demand and the high cost of storage render the utilization of all the LPG that is produced throughout the year a difficult task.

However, we feel the pressure of public opinion and the responsibilities of our office will not permit us to long tolerate the continued flaring of the sizable quantities of LPG which has been taking place. We hope the industry will solve the problem itself, and we extend our co-operation in seeking a solution.

But if a solution is not forthcoming, it would appear to be the duty and responsibility of the Commission under the recent Hyser and Flour Bluff court decisions to prohibit such flaring of LPG. As an intermediate step, we will probably take the total production of LPG into the overall petroleum hydrocarbon picture and if there is insufficient market for LPG to prevent flaring we will start cutting back on the production of all petroleum hydrocarbons.—W. J. Murray, Chairman, Texas Railroad Commission, Austin.

Is it likely that the gas turbine will, or could, replace the reciprocating engine—such as Diesel or gas types?

I do not anticipate personally that the gas turbine will put the Diesel engine out of business. The situation I look for as far more likely is that the gas turbine and Diesel engine will supplement rather than replace each other. The gas turbine probably will be built in much larger capacities than the Diesel engine, so there will not be direct competition in most applications.

It should be emphasized that the gas turbine is no longer a toy. It now has taken over entirely the high-speed military aircraft field. No modern fighter plane or bomber is being powered with piston-type engines, including the high-speed type which now holds the world speed record of 670 mph. I think that five years hence some of the planes you will ride on the commercial air transport lines will not have engines like those now used on the DC-6, but will be gas turbine-powered. I predict further that, within ten years, we will not see any piston-type engines on high-speed commercial transport aircraft.

Another potentially large application is in the locomotive field. We all know Diesel engines have done an excellent job powering locomotives, rapidly replacing the steam type. But what may not be so well known is that there are a number of locomotives now being planned and built with gas turbine engines. Two of them will be on the road soon, using coal. It is entirely conceivable that the gas turbine, sometime in the future, will do to the Diesel-type locomotive what the Diesel already has done to the steam locomotive.—J. T. Rettaliata, Consultant, Allis-Chalmers Mfg. Co., Milwaukee, and Dean of Engineering, Illinois Institute of Technology, Chicago.

Can a gas turbine be used to advantage in oil field service?

I believe the application of a gas turbine in oil field service would have a number of advantages. In the first place, it is possible to build a gas turbine cycle which requires no water whatever. This would be a particularly desirable feature. Also, it can burn almost any kind of liquid or gaseous fuel, from a Bunker "C" liquid fuel to natural gas. Considering the fact that it has purely rotary motion without any reciprocating inertia forces, the maintenance costs should be low.

We have some background on this point and, as you may know, gas turbines have been used to a rather large extent in certain oil refineries, employing the Houdry catalytic cracking process. These units now have a background of somewhat over ten years' experience. Some individual units have run continuously for as long as three years without a shutdown of any kind, representing availabilities of the order of approximately 98%.

Therefore, from the maintenance and reliability standpoint, plus these other features of not requiring water and burning almost any kind of fuel, I believe these characteristics indicate that the gas turbine is rather ideally suited for oil field operation.—J. T. Rettaliata, Consultant, Allis-Chalmers Mfg. Co., Milwaukee, and Dean of Engineering, Illinois Institute of Technology, Chicago.

If propane containing hydrogen sulfide had been stored in a tank, what steps would be necessary before storing sweet propane in the same tank to avoid souring the sweet material from the liquid normally remaining in the tank?

The quantity of contamination of the propane with H_2S will be the deciding factor in the procedure to use in disposing of the H_2S.

If propane contains only a slight amount of H_2S, it is possible to remove most of it by venting, since it tends to predominate in the vapor. This procedure would probably be good only for industrial or utility users where equipment is not so sensitive to H_2S corrosion. Also, the presence of H_2S in a tank usually results in formation of free sulphur—an equally corrosive contaminant which cannot be removed by venting.

However, to completely free a tank

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of H_2S contamination, all the liquid and vapor must be removed from the tank. Furthermore, unless the product in question can be cleaned up so as to meet specifications, it should be flared. Certainly, such product should not be allowed to go out into the regular distribution channels of LP-Gas to domestic users because of the high susceptibility of copper (in tubing) to corrosion by H_2S.

If the tank was clean, and some propane was pumped in which only contained a small amount of H_2S, complete purging with water would be adequate. However, if the contamination is of long standing with the possibility of residues, precipitates, or other "gunk", steaming of the tank is recommended. All parts of the tank should be heated up to a point well in excess of 200 F, and held at this temperature for perhaps an hour. The steam should be introduced at the top of the tank, with the condensate going out through a bottom opening.

Because of the seriousness of the situation, from a safety and economic viewpoint, complete and adequate tests should be run on the tank to determine that the H_2S has been fully removed from the tank before putting it back into LP-Gas service. —J. K. Smith, Field Engineer, Liquefied Petroleum Gas Assn., Inc., Chicago.

Give a resume of the methods used to combat carbon dioxide corrosion in the overhead system of absorption oil strippers.

I do not know any way of preventing such corrosion except either to get rid of the carbon dioxide or, still more important, to be sure that the gas sources are free of oxygen. We have had intermittent experience with gases containing either or both carbon dioxide and hydrogen sulfide in large quantities. In general, gases containing either or both of these materials are not particularly corrosive under ordinary plant operating conditions in the complete absence of oxygen. The tiniest percentage of oxygen present in the raw gas, however, will set fire to the corrosive nature of those gases.

One of the worst cases of high pressure gas corrosion I ever ran into was in Kettleman Hills about 15 years ago, where the analysis of the gas showed carbon dioxide in amounts down to tenths of a percent, say around a quarter of a percent, and an almost unanalyzable percentage of oxygen. This particular plant was a very large one. It was discovered that corrosion was going on when a little puff of gas blew up in the yard one afternoon. Operators thought that was odd and immediately shut down the plant. Investigation

indicated the larger part of the piping system handling the gas to the yard was down to the danger point with internal corrosion. This was traced back to a very small amount of gas derived from a vapor recovery system, taking feed from ordinary flat or cone top storage tanks. The cure was first to replace the corroded pipe, and then eliminate that part of the plant gas which came from the sub-atmospheric pressure source.

In general, it has been pretty well established that gases from wells under pressure do not contain oxygen. If oxygen gets into the system it has to get in from some part of the plant or gathering system which is operating below atmospheric pressure. — Henry Wade, Consultant, Stearns-Roger Mfg. Co., Denver.

Is there any quantitative evidence or experience which indicates the approximate rate or degree to which condensate deposited in the reservoir might go into solution in "dry" gas?

The rate at which condensate in a reservoir would go into solution in dry gas, in my judgment, would be dependent entirely on where the dry gas is put back into the reservoir. For example, if the dry gas were returned to the crest of the reservoir I do not believe there would be mixing of any consequence. If, on the other hand, the dry gas was injected down on the flanks of a wet-gas structure and in the process of production, through the pressure differential caused by that injection, cause the dry gas to migrate upwards, I believe there would be a pretty high rate of absorption of the condensate by the dry gas.—E. O. Bennett, Consulting Engineer, Houston.

Do you recommend the installation of refrigeration equipment for increasing plant capacities and efficiencies?

If you have an old plant where the capacity and volume of gas is coming into a fixed oil circulation for the plant, refrigeration is one way of attacking the problem. In order to make a specific answer to this question, it is necessary to have all factual design data on the plant, as well as the requirements of increasing capacities and efficiencies.

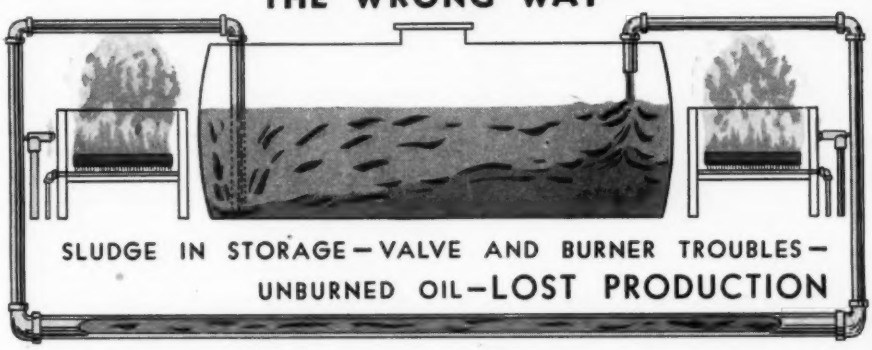
Another way of solving the problem of increasing capacities and efficiencies of a plant is by increasing the absorption pressure, especially if there is a possibility of a residue gas sale. This may require the installation of a higher pressure absorber, together with the additional equipment of pumps, etc.

By following the higher absorption pressure route, it is possible to reduce the amount of oil circulated per 1000 cu. ft. to obtain the same plant efficiencies. Therefore, with a plant having a fixed oil circulation rate and the higher absorption pressure requiring less oil rate per 1000 cu. ft. to obtain the same efficiencies, it is obvious that you can get more gas through your plant by going to the higher absorption pressure and utilizing a lower absorption oil gas ratio. The higher absorption pressures will no doubt require the installation of additional compressors.

In the case of refrigeration, you doubtless will require the installation of refrigeration compressor capacity. Therefore the solution necessitates a study of the economics of the individual plant and design, whereby either refrigeration or higher pressure absorption could be utilized.—H. W. Manley, Vice-president, Barnsdall Oil Co., Tulsa.

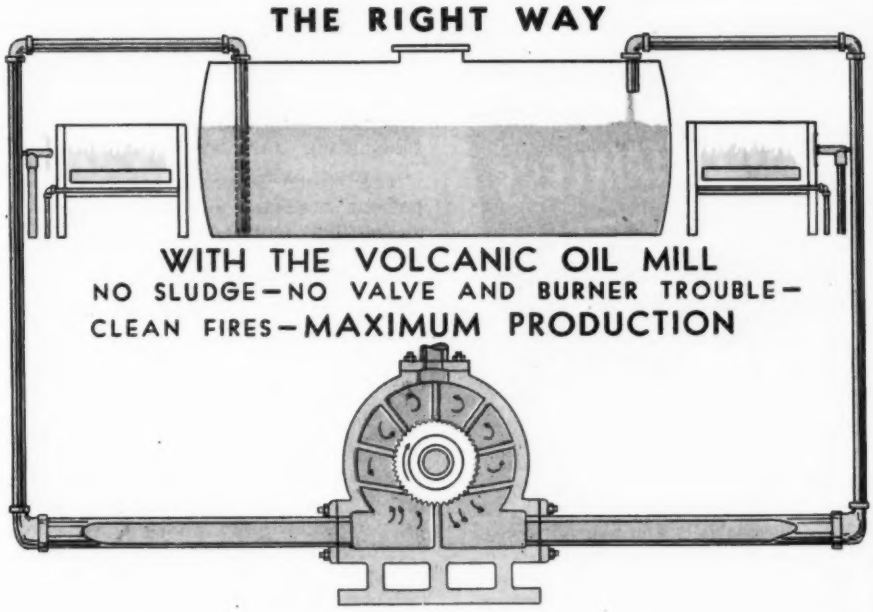
TWO WAYS OF BURNING OIL

THE WRONG WAY



SLUDGE IN STORAGE—VALVE AND BURNER TROUBLES—
UNBURNED OIL—LOST PRODUCTION

THE RIGHT WAY



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Third Edition of Nelson's Refining Text Is Published

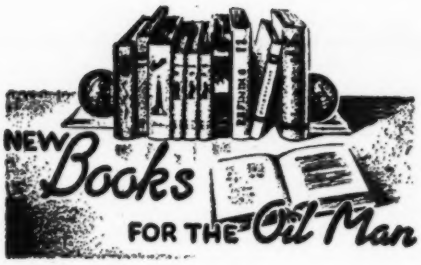
Petroleum Refinery Engineering, Third Edition; by W. L. Nelson: 6 x 9 in., xii + 830 pages, stiff cloth binding, illustrated, indexed, $9.00. McGraw-Hill Book Co., Inc., New York City.

It is indeed superfluous to point out that a new, revised edition of *Petroleum Refinery Engineering* has been needed because of the tremendous progress made in this field since the last previous edition was issued —before the War, in 1941.

Every effort has been made by Dr. Nelson to incorporate as much as possible the huge amount of detail that has grown up in the industry. Parts of the earlier editions had had to be deleted entirely, particularly those chapters on basic chemical engineering which now are covered thoroughly in standard chemical engineering textbooks and handbooks.

The recent war brought forth such outstanding new processes as alkylation, isomerization, butane dehydrogenation, for example, that these are of necessity covered in the present volume. It is therefore quite unfortunate that the publishers delayed publication of this book for so long a time following its completion. The most recent references listed in the excellent bibliographies for each chapter are dated no later than the fall of 1947. It would seem an earlier publication date for the book would have made it considerably more up to date.

The author is a consulting chemical and petroleum engineer, and is professor of petroleum refining at the University of Tulsa.



History of Oil Development In the Southwest Is Told

Oil! Titan of the Southwest, by Carl Coke Rister: 6 x 9 in., xxiv—467 pages, stiff cloth binding, illustrated, indexed, $5.00. University of Oklahoma Press, Norman, Okla.

In September, 1945, the Standard Oil Co. of New Jersey made a research grant (subsequently increased) to the University of Oklahoma Foundation to aid in compiling necessary data and writing a history of oil development in the Southwest.

Mr. Rister, research professor of American history at the University of Oklahoma, who has written a number of other notable books on the Southwest during the past two decades, was chosen for the task and given a leave of absence from his teaching duties. In seeking data, Mr. Rister traveled by automobile and train more than 35,000 miles, assembling nearly 10,000 copied pages of information, hundreds of oil field, town, and refinery photographs, microfilms, photostats, maps, charts, and out-of-print publications. From this mass of material he created his fascinating narrative of events.

The result is gratifying. Only the patient historian could present such a detailed story of oil's growth in that section of the U. S. which now accounts for almost two-thirds of the nation's crude oil production.

The book is almost a well-by-well account of the successful attempts and the failures in each of the six states comprising the region, giving dates, names, and places carefully documented from the early days right down to the present time. Mr. Rister, by emphasizing the significance of petroleum—its constant, persuasive influence on our political, economic, and social life—has filled a gap left by other historians purely through neglect of the subject.

Government Publications

Questions and Answers on Propane and Butane Fuels, Information Circular 7519; U. S. Dept. of Interior, Bureau of Mines, by J. F. Barkley, Chief, Fuels Utilization Branch: 8 x 10½ in., 9 pages, no charge. Copies may be obtained by writing the Bureau of Mines, Publications Distribution Section, 4800 Forbes St., Pittsburgh 13, Penna.

MEETINGS . . . for the Oil Man

AUGUST

15-17, Society of Automotive Engineers, National West Coast Meeting, Multnomah Hotel, Portland, Ore.
17-Sept. 6, United Nations Scientific Conference on the Conservation and Utilization of Resources, U. N. Interim Headquarters, Lake Success, N. Y.
Aug. 19—Western Petroleum Refiners Assn., regional meeting, Leonard Refineries, Inc., Alma, Mich.

SEPTEMBER

6-8, American Institute of Chemical Engineers, Regional Meeting, Mount Royal Hotel, Montreal (Que.), Canada.
9-12, Instrument Society of America, Clinic on the Maintenance of Industrial Instruments, Statler Hotel, St. Louis.
12-16, American Society of Mechanical Engineers, Instruments and Regulators Division Conference and Exhibit, Municipal Auditorium, St. Louis, Mo.
12-16, Instrument Society of America, Annual Conference and Exhibit, Municipal Auditorium, St. Louis, Mo.
14-16, National Petroleum Assn., Hotel Traymore, Atlantic City, N. J.
18-23, American Chemical Society, 116th National Meeting, Atlantic City, N. J.
24-27, American Institute of Mining & Metallurgical Engineers, Regional Meeting, Neil House, Columbus.
28-30, American Society of Mechanical Engineers, Fall Meeting, Lawrence Hotel, Erie, Pa.
30-Oct. 1, Colorado School of Mines, Mineral Resources Conference, Golden, Col.

OCTOBER

2-5, American Society of Mechanical Engineers, Petroleum Division, Petroleum Mechanical Engineering Conference, Biltmore Hotel, Oklahoma City.
3-4, National Assn. of Corrosion Engineers, South Central Regional Meeting. Adolphus Hotel, Dallas.
3-5, National Lubricating Grease Institute, Annual Meeting, Roosevelt Hotel, New Orleans, La.
7, California Natural Gasoline Assn., 24th Annual Fall Meeting, Ambassador Hotel, Los Angeles.
10-14, American Society for Testing Materials, First National West Coast Meeting, Fairmont Hotel, San Francisco.
14, Natural Gasoline Assn. of America, Southern Regional Meeting, Blackstone Hotel, Tyler, Texas.
17-21, American Society for Metals, Annual Meeting, Public Auditorium, Cleveland.
17-21, American Welding Society, Annual Meeting, Public Auditorium, Cleveland.
20-21, American Institute of Mining & Metallurgical Engineers, Fall Meeting, Petroleum Branch, Elk's Club, Los Angeles.
26-27, American Society of Mechanical Engineers, Fuels Division Conference. French Lick Springs Hotel, French Lick, Ind.

NOVEMBER

1-5, 2nd Pacific Chemical Expo, San Francisco Civic Auditorium, San Francisco.
1-5, American Chemical Society, Petroleum Division, California Section, San Francisco Civic Auditorium, San Francisco.
3-4, Society of Automotive Engineers, Fuels & Lubricants Meeting, Chase Hotel, St. Louis, Mo.
7-10, American Petroleum Institute, Annual Meeting, Stevens Hotel, Chicago.
27-Dec. 2, American Society of Mechanical Engineers, Annual Meeting, Hotel Statler, New York.
28-Dec. 3, 22nd Exposition of Chemical Industries, Grand Central Palace, New York.

DECEMBER

4-7, American Institute of Chemical Engineers, Annual Meeting, William Penn Hotel, Pittsburgh.
9, Natural Gasoline Assn. of America, Panhandle-Plains Regional Meeting, Herring Hotel, Amarillo, Texas.

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Personals

Franklin LeRoy Newcomb, a design consultant specializing in equipment safety in the Esso Engineering Department of Standard Oil Development Co., retired June 29 after nearly 32 years service. He is one of the originators of metals and safety inspection on equipment of the refining industry, and is recognized as one of the authorities in this field.

Mr. Newcomb

Mr. Newcomb was born in Elizabeth, N. J., and received a degree in mechanical engineering from Cornell University. With the exception of a year with an affiliated company in South America, all of his Esso service has been in the Elizabeth area. He is a member of the ASME and the API.

* * *

John M. Brackenbury, refinery assistant superintendent at Shell Oil's Martinez, Calif., refinery, was named superintendent of the Montreal refinery of Shell Co. of Canada, Ltd., effective June 16. Mr. Brackenbury, a native of Colorado, joined Shell in 1933 as a laboratory inspector at the Wilmington refinery. He has held several technical positions and became assistant superintendent at Martinez in 1946.

* * *

John W. Newton, vice president and manager of refining with Magnolia Petroleum Co., was recently admitted into the Texas Delta chapter of Tau Beta Pi, honorary professional society for engineers.

* * *

O. B. Males, superintendent of the refinery division of the Saskatchewan Federated Co-operatives, Ltd., Regina and Saskatoon, Canada, retired recently. His former asst. superintendent, **B. W. Pawson,** will succeed him. Mr. Males joined the Saskatchewan Co-Operatives in 1935 to design and erect the world's first co-operative refinery. He plans to take up residence in the United States.

* * *

George L. Macpherson has been appointed general manager of refineries for Imperial Oil Ltd. of Canada. He was formerly manager of the engineering and development division of the manufacturing department. Mr. Macpherson joined Imperial in 1922 as a draftsman. In 1937 he was made asst. chief engineer and in 1943 was given the post of chief engineer. His home is Markdale, Ont., and he is a graduate of the University of Toronto.

* * *

Charles A. Larson has been employed by the Standard Oil Co. (N. J.) as an engineering and economic consultant in the Coordination and Economics Department in New York. Following his graduation from Rensselaer Polytechnic Institute in 1941, he went with Standard Oil Development Co. in process test and engineering research work. Granted a Teagle Scholarship in 1947, he obtained a leave of absence to attend Harvard Business School, from which he recently received his M. S. degree in business administration.

* * *

Bruce K. Brown will be president of the new Pan-Am Southern corporation to be formed by the merger of Pan American Petroleum Corp. of New Orleans and its subsidiary, Root Petroleum Co. of Shreveport, La. Mr. Brown is now president of the Pan American Petroleum Corp., as well as vice president and director of Standard Oil Co. (Ind.), the parent company.

Mr. Brown

Mr. Benton

The merger plan was approved July 25 by directors of the two merging companies, but is subject to ratification by the stockholders.

Dwight F. Benton, president of Root, will be advanced to another position with Indiana Standard upon consummation of the merger, according to A. W. Peake, president of the parent company.

* * *

C. J. Mowery has been named process superintendent for Carter Oil Co.'s new refinery now nearing completion at Billings, Mont. **Herman G. Gunter** had previously been announced as general superintendent of the plant.

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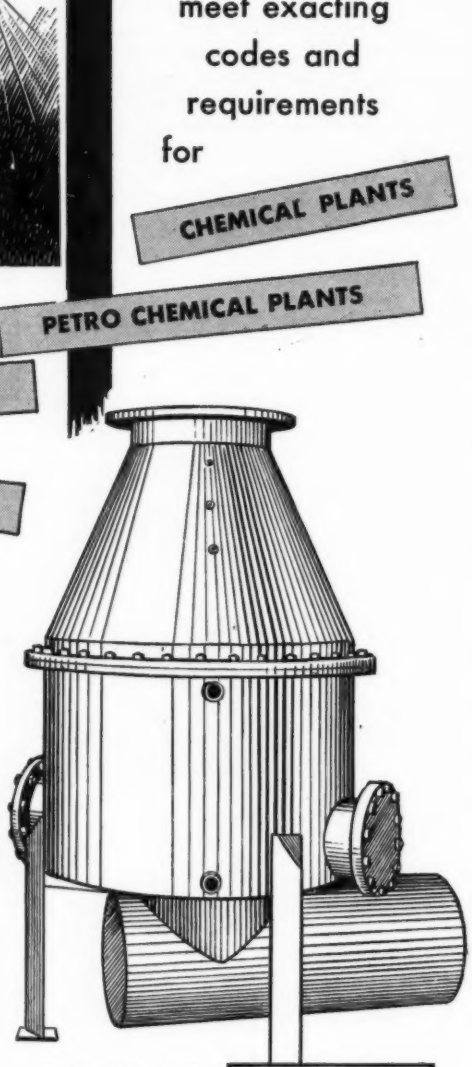

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Personals

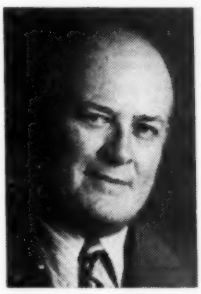
Other operating personnel named include the following: **Robert E. Boydston,** chief engineer; **James W. Bateman,** technical department head; **W. G. Hockbarger,** chief chemist; **George D. Spooner,** general mechanical foreman; **R. W. Burns,** catalytic unit foreman; **Charles F. Moberly,** crude oil fractionating unit foreman; **M. A. Price,** treating foreman; and **J. S. Bernier,** planning engineer.

* * *

G. E. Wynn has been elected vice president in charge of manufacturing for Mid-Continent Petroleum Corp., and **D. Glenn Morgan** director of research and development, a newly-created department.

Mr. Wynn

Mr. Wynn for the past four years has been refinery superintendent. A graduate of the University of Kansas, he joined Mid-Continent as a utility engineer in 1924. In 1935 he was named engineer in the planning and development department, and two and a half years later became department superintendent. Late in 1938 he was named to supervise the operating departments of the refinery. He became asst. general refinery superintendent in 1942, and three years later superintendent.



Mr. Morgan

Mr. Morgan, a graduate chemist from Ohio University, joined Mid-Continent in 1917. He advanced steadily, filling the positions of chemist, asst. transfer foreman, asst. process superintendent, process superintendent, asst. general superintendent, and general superintendent. He was named manufacturing manager of the company's refinery in 1945, a post he held until his present appointment.

* * *

R. L. Nichols, instrument shop foreman at Magnolia Petroleum Co.'s Beaumont, Texas, refinery, has been named area vice chairman within the South Texas section of the American Society of Mechanical Engineers for the year July 1, 1949, to June 30, 1950.

* * *

Dr. William J. Peppel has been appointed director of the new Austin, Texas, research laboratories of Jefferson Chemical Co., petrochemical firm owned jointly by The Texas Co.

Personals

and American Cyanamid. Manager will be **Charles H. Novotny.** Dr. Peppel will have charge of technical activities, while general management will be in the hands of Mr. Novotny. Assisting Dr. Peppel will be **John W. Waldron,** asst. director of the laboratories and director of the process development division.

* * *

Earl G. DeWitt, recent recipient of a Ph. D. in organic chemistry from Ohio State University, now holds a position as research chemist in the laboratories of the Ethyl Corp., Detroit.

* * *

E. W. Riblett has been moved from the New York office of M. W. Kellogg Co. to Jersey City, N. J., as associate director of the petroleum and chemical research laboratory.

* * *

L. A. Whitlock has been elected vice president in charge of refining of the Douglas Oil Co. of California, and **John J. Stanko** vice president in charge of research and asphalt specialties.

* * *

John H. Schaefer, vice president in charge of manufacturing for the Ethyl Corp., is new president of the Industrial Research Institute. The institute is composed of more than 110 companies representing widely varied industries. It is interested primarily in establishing high standards in industrial research and in developing improved techniques of organization and operation in research activities.

Mr. Schaefer

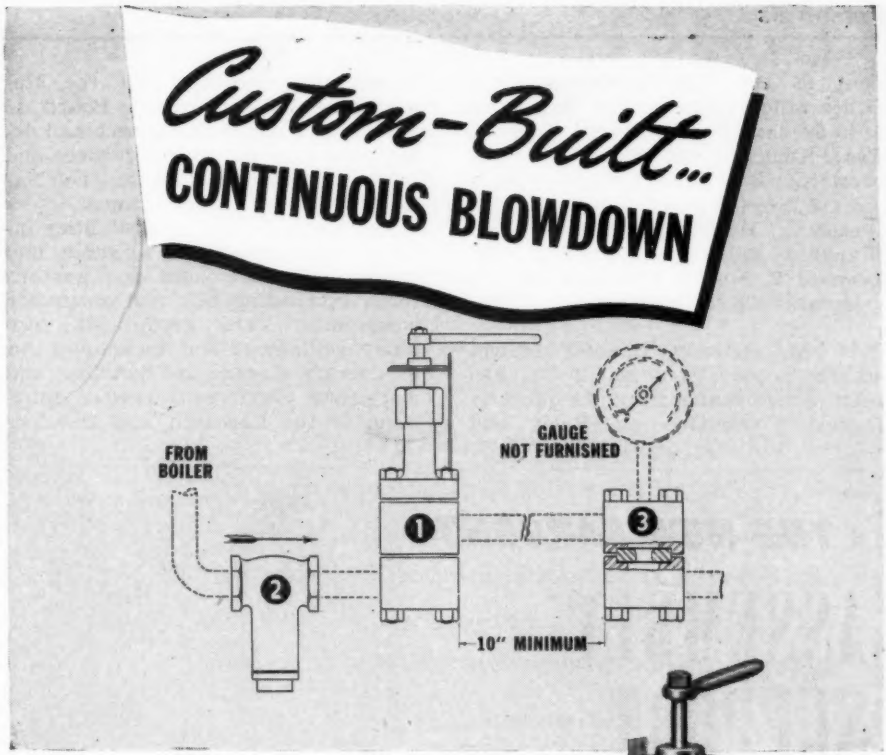
Mr. Schaefer, who was vice president of the institute last year, has been with Ethyl for 23 years, and has been vice president of the company since 1943. He lives in Baton Rouge, La., where Ethyl's antiknock manufacturing plant is located.

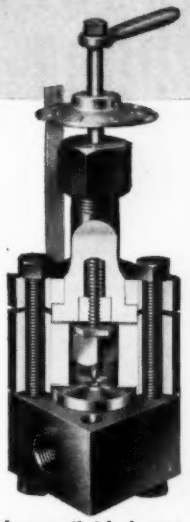
* * *

After 41 years with Tide Water Associated Oil Co., **Paul L. Rafford,** asst. supervisor of the manufacturing accounting department of the Bayonne Refinery, retired July 1. Mr. Rafford started with the company in 1908 as a clerk at a refinery warehouse. Upon his retirement, he was given a gold wrist watch at a dinner held for him by his fellow employes.

* * *

Dr. Howard L. Yowell, a member of the research staff at the Esso Laboratories of Standard Oil Development Co., has been elected presi-





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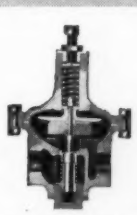

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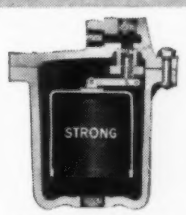

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dent of the Esso Research Club. Other officers elected for the club's 1949-50 season are: **Harry T. Rice,** Esso Standard Oil Co., first vice-president; **Dr. Carl S. Carlson,** Standard Oil Development Co., second vice-president; **Herbert L. Minich,** Esso Standard Oil Co., secretary; **Dr. Leonard E. Moody,** Standard Oil Development Co., treasurer.

* * *

W. M. Holaday, director of research, Socony-Vacuum Oil Co., has been named chairman of the recently formed Committee on Fuels and Lubricants, organized by the Research and Development Board to determine policies on research and development in the field of fuels and lubricants as they affect the National Military Establishment.

The committee's responsibilities include consideration of organic and inorganic liquids, solid and gaseous fuels, lubricating oils and antifreeze compounds. The group will also study equipment and techniques for production, storage and handling, and dispensing; and will assume functions of the Research and Development Board's Panel on Petroleum, which had been working on problems in the field of petroleum since July, 1948.

* * *

Thomas V. Sheehan, asst. head engineer, light-oil design, Standard Oil Co. (Ind.), has been loaned by the company to Associated Universities, Inc., at Brookhaven National Laboratory, Upton, N. Y., as operating consultant on the new nuclear reactor and auxiliary equipment.

* * *

Robert V. West, Jr., has joined the Slick-Urschel Oil Co., San Antonio, where he will be concerned with the processing of light hydrocarbons. He was formerly on the technical service staff of Humble Oil & Refining Co. at the Baytown refinery, and had also served as research associate for the Reconstruction Finance Corp.'s Office of Rubber Reserve on a special project at the University of Texas. He obtained his Ph. D. degree in chemical engineering this year from the university.

* * *

Richard N. Burnley, asst. department manager in the chemicals division of Shell Oil Co.'s Wilmington, Calif., refinery, has been moved to the firm's San Francisco offices.

* * *

Richard K. Wildermuth has been transferred to the technical department of Socony-Vacuum's East St. Louis, Ill., refinery. He was previously in the engineering department in Socony's New York offices. **Judson B. Parker,** foreman of the pipe line department at the East St. Louis plant, has been named technical assistant to the maintenance superintendent for Raffineria de Napoli, S.P.A., in Naples, Italy.

* * *

William D. Harbert has resigned his position as process engineer with Lion Oil Co., El Dorado, Ark., to join the research department of Pittsburgh Consolidation Coal Co. at Library, Pa.

* * *

H. C. Meiners has been appointed asst. manager of Union Oil Co. of California's refinery at Oleum, Calif.

* * *

E. B. Palmer has been promoted to the new position of asst. manager at the Los Angeles refinery of Union Oil Co. of California. Other promotions at the plant include **M. S. Thompson** to superintendent of cracking, and **Frank Van Acker** to asst. superintendent of cracking.

* * *

Development of a method of using gas instead of oil for fuel in Socony-Vacuum's Atlas refinery at Buffalo, N. Y., brought a $1300 award under the company's suggestion system to **Arthur L. Clark,** a clerical employee without production or supervisory responsibilities. It was the largest

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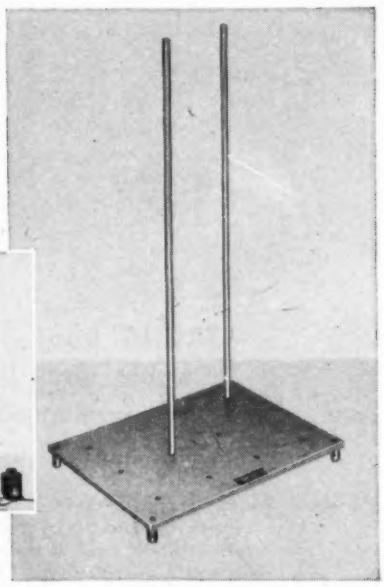

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Consisting of a heavy gauge aluminum plate, available in two sizes, supported by four adjustable feet, for leveling, and tapped and threaded at convenient intervals to receive stainless steel rods, this new support stand has qualities of stability, rigidity and flexibility of application not found in other conventional type stands.

The stainless steel rods are threaded at one end and tapped at the other, giving the operator a variety of heights in one foot increments as well as a wide selection of lateral distances at which the rods may be placed. For setups having large lateral distances two or more of these bases may be locked together by crossbracing an upright on one to an upright on another. Any conventional clampholder of sufficient size to fit the rods will work satisfactorily.

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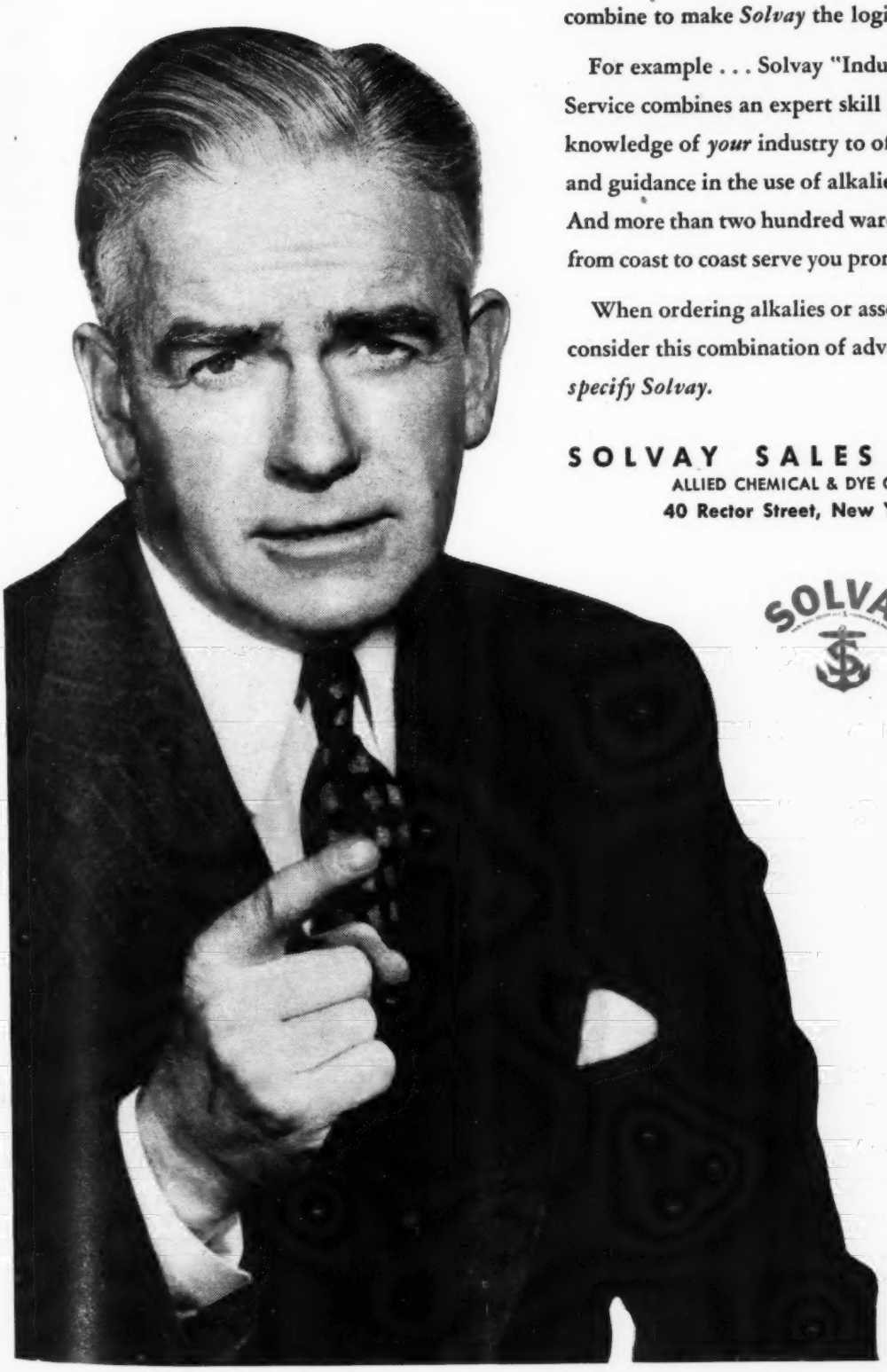

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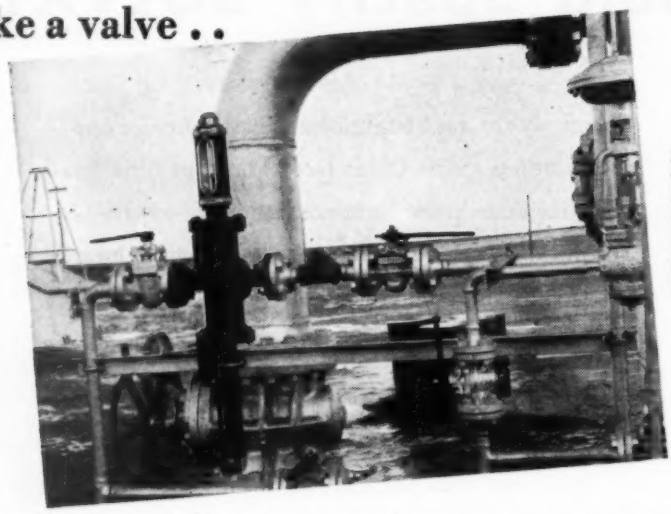

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Personals

award since the suggestion system was revised and installed throughout the company two years ago. Mr. Clark started work at the refinery in 1934, and saw three and a half years' Army service in Australia, New Guinea and Luzon, being discharged with the rank of major.

* * *

James R. Cameron has left Stanolind Oil & Gas Co. to join the research staff of Battelle Institute, Columbus, Ohio, where he will do research in nonferrous metallurgy.

* * *

F. C. King has been appointed asst. manager of General Petroleum Corp.'s engineering department. Mr. King is a native of Toledo, Ohio, and a graduate of California Institute of Technology, where he received his degree in applied chemistry in 1935. He joined General Petroleum in 1941 as an inspector, advancing to the post of refinery engineer in 1946. From 1946 until the present promotion he has worked at the company's Torrance, Calif., refinery, chiefly on maintenance engineering.

* * *

Garrard E. A. Wyld has returned to Shell Development Co., Emeryville, Calif., after receiving a Ph. D. in analytical chemistry at the University of Illinois.

* * *

A. Jonnard is now a member of the economic research department of Shell Chemical Corp., in New York City. He recently received a Ph. D. in chemical engineering from the University of Pittsburgh.

* * *

James L. Cartisser, kilnman at Tide Water Associated's Bayonne, N. J., refinery, recently was awarded $1500 as first prize for the best idea submitted in the company's suggestion plan during 1948. His prize-winning suggestion was concerned with a method for reducing catalyst losses from catalytic cracking units.

* * *

David S. Frank has been appointed to the newly-created post of manager at Pure Oil Co.'s Toledo refinery. He was formerly refinery superintendent, a position now held by **Hal. S. Dronberger.**

* * *

Roger B. Jones has been appointed director of industrial relations for the Sinclair Oil Co., with headquarters in New York.

* * *

Charles B. Barry, formerly senior process engineer with Phillips Petroleum Co., has joined the oil and gas department of Blaw-Knox Co.'s Chemical Plants Division as chief engineer. He will make his headquarters in Tulsa, where the company has recently opened a new district office.

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EDITORIAL VIEWPOINTS...

Opinions and Comments on Current Topics

Congress Must Write the Rules

A DECISION of the Supreme Court a few weeks ago in effect strengthened the oil and gas industries' interpretation of the existing Natural Gas Act, in stating that the Federal Power Commission has no authority to regulate any part of the production and gathering of natural gas.

In the latest decision the Supreme Court affirmed a lower court order denying an injunction sought by the FPC to halt the Panhandle Eastern Pipe Line Co. from disposing of leased gas lands in Kansas. The majority opinion, read by Justice Reed, stated the Natural Gas Act did not envisage federal regulation of the entire natural gas field to the limit of constitutional power. Rather, it specified the exercise of federal power to complement that of the state regulatory bodies, and to be limited to (1) transportation of natural gas in interstate commerce, (2) its sale in interstate commerce for resale and (3) companies engaged in such activities.

The Supreme Court decision of some two years ago seemed to place the opposite interpretation on the act. In the Interstate Natural Gas Co. case the authority of the FPC was upheld in regulating sales of gas in Louisiana where the gas was scrubbed and processed before being moved with other gas across the state line. In this case the court held that FPC, in carrying out its rate-making activities, could consider the fair value of producing and gathering facilities in arriving at rate bases. In its recent decision the court attempted to bridge the gap between the two rulings by declaring that the gathering of data on producing and gathering operations for rate-making purposes was not a precedent for the commission to regulate any part of production or gathering operations. The transfer of leases, it was held, was an activity related to production and gathering of gas.

As long as the interpretation of the powers granted the Federal Power Commission under the Natural Gas Act remains with the courts, confusion will exist as to the extent of regulatory power the FPC can assume.

The remedy for the situation lies in the passage of an amendment to the present Natural Gas Act which will clearly define the authority of the regulatory agency, as is proposed in Bill H.R. 1758, now before Congress.

Machine Shop Supplies De Luxe

THE inflated importance assigned to the Bureau of Mines Synthetic Liquid Fuels Program by some of the Bureau officials is illustrated by the case presented before Congress to restore $250,000 to the appropriation for this work for the fiscal year 1950. The Bureau of the Budget approved $10,000,000 for the synthetic fuels program, but this amount was reduced to $9,750,000 by the House, with the suggestion that the unused balance of the contractual authority be used to provide for changes in equipment and plant design.

At a hearing on the appropriation, a Bureau official appeared to tell how the changes in equipment and plants at the Coal and Oil Demonstration plants at Louisiana, Mo., could best be made with existing personnel and equipment. To that end it was proposed that the equipment be constructed and erected in the machine shop there. Since the supplies and materials used in the fabrication of the equipment could not be purchased under contractual authority, it was proposed that the $250,000 lopped off by the House be restored to provide for such items.

By contrast, the appropriation for 1949 for the Bureau's work related to petroleum and natural gas, for the administration, operation and maintenance of the Bartlesville Petroleum Experimental Station is $131,530. The appropriation for work in the primary extraction of crude oil and natural gas is $159,440; that for studies in the chemistry and refining of petroleum, $111,420; for experiments in secondary recovery, $144,300; for studies in transportation and storage of oil and gas, $7620.

It is to be hoped the difference in the appropriations does not truly reflect the views of the Bureau's top officials as to the importance of its work in petroleum and gas.

Du Pont President Sets an Example

PRESIDENT Crawford H. Greenewalt of the du Pont company was in a spot last month in which a good many businessmen can expect to find themselves as the administration builds up its antitrust campaign. He could be cautiously silent about the antitrust suit against du Pont, on the theory that the less said the better about his company's troubles with the government; or he could speak his mind.

As is his right as an American, President Greenewalt chose the latter course. Promising a full answer to the Department of Justice's charges in court later, he said that "many of the charges are of no substance, some are completely unfounded or grossly exaggerated." He pledged a fight "with all possible vigor on this unjustified attack."

His statement contained such phrases as "this charge has no basis in fact," "such allegations show either ignorance of the most elementary economics or willingness to distort the significance of the fact."

Thwarted from several of its objectives by a Congress which refuses to be herded, the Truman administration is going to put out a lot of ballyhoo along the lines of its antibusiness election campaign last fall. Mr. Truman himself sounded the keynote in a recent radio speech in which he started what apparently will be a studied effort to blame the recession on "selfish interests."

The managers and leaders of industry and business—including refining—can take these jibes in silence or they can answer back. Their pussyfooting and that of the Republican party last fall gave Mr. Truman the election by default. Mr. Greenewalt of du Pont is one businessman who expects to fight it out from now on.

If others join him—speaking openly, honestly, forcefully and promptly when the record of industry in general or their own companies in particular is falsified—the voters can be expected to have a better understanding of the issues the next time they go to the polls. If they are silent, they can blame no one but themselves for whatever may happen. —P.W.

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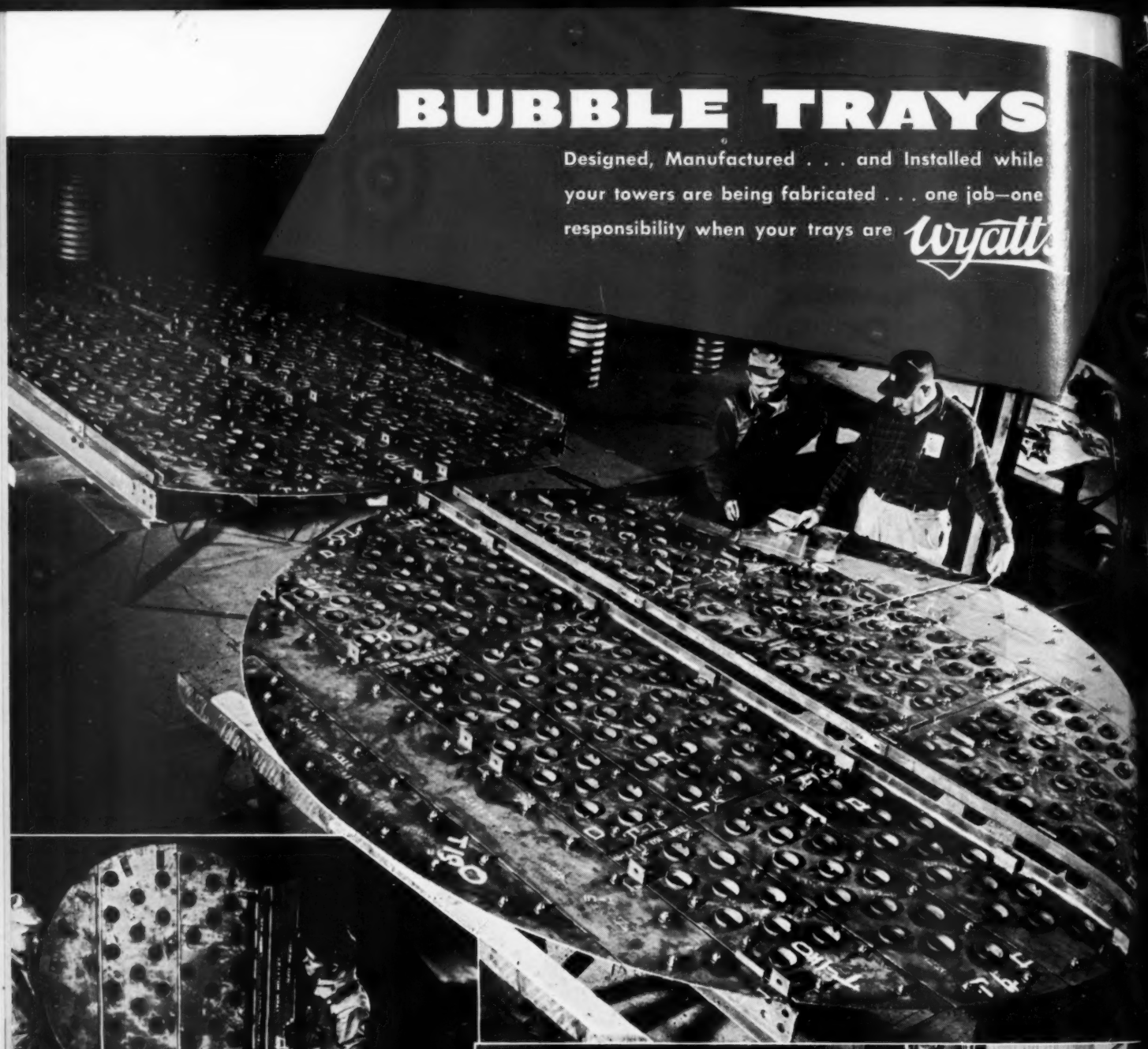

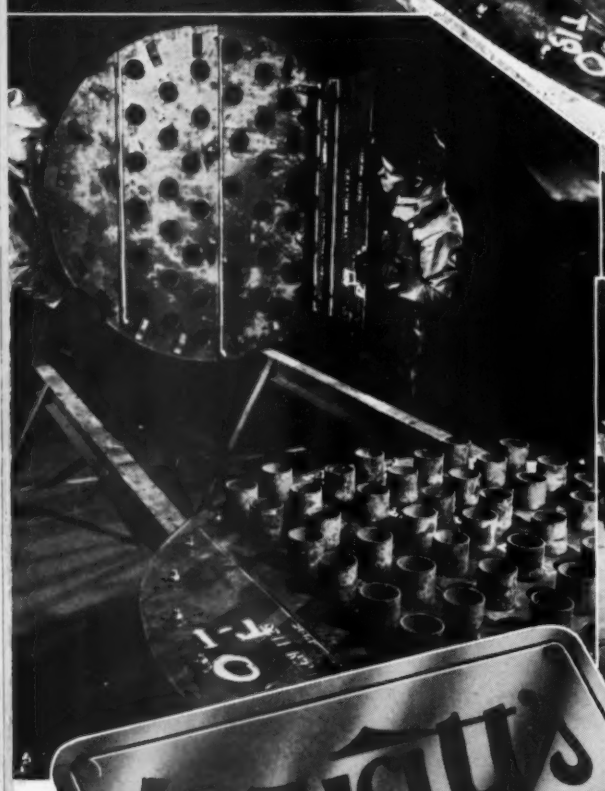

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